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PHOTODOCUMENTATION OF LONG-TERM LUNAR SURFACE EXPOSURE EXPERIMENT

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16. Abstract

Preflight photographs of selected Apollo 17 equipment taken for use in determining the effects on various surfaces of long-term exposure to the lunar environment are presented. Photographs of the articles deployed on the lunar surface also are included. The photographic procedure and the coding system used for the photodocumentation are explained. Other documentation measures planned to obtain items for use as controls in projected analyses are discussed.

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FIGURES

PHOTODOCUMENTATION OF LONG-TERM LUNAR SURFACE EXPOSURE EXPERIMENT

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SUMMARY

Results of the analyses of Surveyor III parts exposed on the lunar surface for 31 months prompted a decision to undertake a study of the long-duration effects of the lunar environment on selected Apollo 17 flight articles. Documentation that included the making of detailed photographs, the incorporation of representative parts into the NASA lunar sample curatorial collection, and the acquisition of detailed engineering drawings and chemical information was planned. The photodocumentation has been completed, and the collection of other documentation into the curatorial facility is progressing.

Because of prelaunch time constraints and time-line restrictions during the Apollo 17 mission, the photodocumentation procedure used was not ideal; however, every effort was made to obtain the best coverage at optimum magnifications as consistently as possible within the limitations imposed. Accordingly, each surface was documented entirely to a resolution of at least 200 micrometers and partly to a resolution of 100 to 60 micrometers. All individual views were photographed in black and white, and at least one overall view and a representative photograph at higher magnification were made in color. For each view, two original negatives were generally taken to ensure obtaining two complete sets of negatives for separate storage. An archival film development method was used; special developers and fixers were applied to ensure excellent reproducibility and minimum deterioration of the negatives during a period of 20 to 30 years.

INTRODUCTION

Surveyor III parts returned during the Apollo 12 mission were analyzed by a variety of investigators concerned with the space environment and its interaction with planetary surfaces such as the Moon. These investigations fell into three basic categories.

1. Solar wind and solar flare studies

2. Galactic radiation studies

3. Micrometeoroid studies

Although premission documentation was nonexistent and although total exposure time of these materials was only 31 months and total surface area was small, significant and in part unexpected results were obtained (refs. 1 to 11).

As a consequence, an attempt was made to include in the Apollo 17 spacecraft a specially designed package to be left on the lunar surface and returned at some future, though completely undetermined, date for investigating exposure effects ranging over periods of decades. A meeting, attended by approximately 20 scientists, was called by D. W. Strangway of the NASA Lyndon B. Johnson Space Center (JSC) and was held at the Lunar Science Institute on March 15, 1972. Detailed design criteria were formulated, and a feasibility study was initiated. However, time-line considerations and weight limitations could not be met and this particular experiment had to be abandoned. It was recommended that already existing surfaces on the Apollo lunar surface experiments package (ALSEP) of Apollo 17 be used to the largest extent possible after careful documentation of the surfaces before launch.

The subsequent documentation of Apollo 17 flight hardware consisted of three general but related activities.

1. Detailed photodocumentation

2. Incorporation of representative parts into the curatorial lunar sample collection at JSC

3. Acquisition of detailed engineering drawings and chemical information

At the time of writing this report (August 1973), the photodocumentation had been accomplished and only part of the other activities had been performed. However, provisions have been made to acquire representative parts from a variety of contractors; approximately 20 percent of all parts are already incorporated in the curatorial collection. These materials are predominantly derived from various backup units or from other material of suitable quality that resembles most closely or precisely the actual flight units. These materials will serve as useful "standards," especially for analytical techniques currently not available. Similarly, some design drawings and other technical information have already been retrieved, and provisions have been made for the various fabricators, upon termination of contracts, to turn over pertinent design drawings to the curatorial office together with the remainder of the representative parts. All pertinent information will be available after the acquisition of these engineering details; therefore, no dimensions, chemical analyses, and the like are given in this report, which deals exclusively with the photodocumentation.

As an aid to the reader, where necessary the original units of measure have been converted to the equivalent value in the Système International d'Unités (SI). The SI units are written first, and the original units are written parenthetically thereafter.

The author thanks the following people for their interest and support in obtaining the photographs: Dr. D. W. Strangway, JSC; W. Ehrlichman, JSC; Jack Ottinger, JSC; P. Benavides, JSC; Dr. J. Sauer, Technicolor Inc.; and various contractor personnel at Bendix Corporation, Ann Arbor, Michigan; at RCA Corporation, Heightstown, Pennsylvania; and at the NASA John F. Kennedy Space Center.

PHOTOGRAPHIC PROCEDURE

It must be clearly understood that only a limited timespan was available to perform the photodocumentation because the various pieces of equipment could be made available for only a short time, typically 2 to 3 hours. It was not possible to arrange (ideally) the photography immediately before stowage in the spacecraft; some pieces had to be photographed even before assembly of the entire instrument. The dates of photography ranged from approximately 5 months to 2 months before lift-off. Thus, the photographs can only reflect the condition of each surface as of the date when the documentation was performed. However, it can be safely assumed that the condition of the surfaces did not change significantly before lift-off.

Because of these time constraints, it was impossible to photograph at high magnification each surface in its entirety; only representative shots at the higher magnifications were possible. Occasionally, the choice of the best photodocumentation had to be made on the spot, and every attempt was made to ensure reasonable coverage at the various magnifications. As a consequence, there was no precise, consistent format for the higher magnifications. However, the procedure followed consistently was to obtain the following.

1. An overall view of the surface, regardless of size

2. A 1:1 "magnification" of the entire surface, regardless of size (The term "magnification" refers to the actual image size on the photographic negative.)

3. A 1:X magnification, depending on the time available or the approach considered best for documentation (The factor "X" may vary from 2 to 4.)

Accordingly, each surface in its entirety was documented to at least a resolution of 200 micrometers and parts of it to a resolution between 100 and 60 micrometers.

All individual views were photographed in black and white. At least one overall view and a representative shot at higher magnification were made in color. The black-and-white film used was Plus-X; the color film was Ektacolor type L. The camera used was a Sinar 10.2 by 12.7 centimeter (4 by 5 inch) view camera. Because of the various reflectivities of the surfaces, a constant lighting setup (i.e., angle, light intensity, etc.) could not be maintained; the setup was changed for each surface to an optimum as revealed by tests with Polaroid film.

For each view, two original negatives were generally taken to ensure having two complete sets of negatives. One set will be stored in the NASA JSC curatorial facilities; the other will be stored at a place not yet determined.

A detailed description of the development procedures was prepared by Technicolor Graphics Services, Inc., and is stored in the curatorial facilities. The salient point is that an archival method was used with the application of special developers and, most importantly, special fixers to ensure excellent reproducibility in the developing and little or no deterioration of the original negatives within a period of 20 to 30 years.

TYPE EXAMPLES

Some representative examples of the variety of surfaces documented together with illustrations of the quality of the closeup photographs are shown in figures 1 to 4. No examples of color photographs can be given. An explanation of coding is given in the following section.

EQUIPMENT PHOTOGRAPHED AND IDENTIFICATION OF INDIVIDUAL PHOTOGRAPHS

The equipment photographed included the color television (CTV) camera, the surface electrical properties (SEP) experiment, the lunar atmospheric composition experiment (LACE), the LACE shield (LS), the helix antenna gimbal housing (HAGH), the lunar heat flow experiment (HFE) electronics box, the lunar ejecta and meteorites (LEAM) experiment, the lunar communications relay unit (LCRU), and the television control unit (TCU). In preparing for publication of the photographs illustrated in figures 5 to 20, the following format, coding system, and symbols were consistently applied.

1. The legend for each figure contains a brief explanation of the surfaces illustrated, the availability of color photographs, the NASA photograph number, and other necessary comments.

2. The coding system used is as follows.

a. The first set of capital letters (e.g., LACE) is the established abbreviation of the instrument photographed.

b. The second capital letter is used to designate the flight unit (F) or the backup unit (B).

c. A third capital letter, if used, designates a specific surface (or side) photographed.

d. A numerical subscript indicates 1:1 magnification; an alphabetical (lowercase letter) subscript indicates a magnification of 1:2 or greater. These subscripts also are frame designators.

The original negatives have been labeled using the coding system just explained. Several examples follow.

1. LS, F_4 - 1:1 magnification of the LACE shield, flight unit, frame 4 (The LS has only one side; thus, no third letter is used.)

2. LS, F_d - 1:3 magnification of part of LS, F_4

3. LACE, F, B_3 - 1:1 magnification of the LACE, flight unit, side B, frame 3

4. LACE, F, B_b - 1:3 magnification of the LACE, flight unit, side B, frame b

LUNAR SURFACE DOCUMENTATION

Because of time-line considerations, no special documentary photography of the photodocumented articles after emplacement on the lunar surface was possible. However, most of the articles were covered by the ALSEP photography requirements. The photographs most suitable to illustrate the various pieces of equipment and to reconstruct the surface orientation are shown in figures 21 to 28.

The LACE and the SEP experiment solar cells are extremely well documented, whereas the positions and conditions of the LACE shield, the HAGH box, and the HFE electronics box are only approximately known. Unfortunately, no photographs of the various mirror surfaces were taken after the lunar roving vehicle (LRV) was parked at its final location. The Apollo 17 CTV camera was oriented horizontally; that is, at zero elevation and 318° azimuth (according to E. Fendell, JSC). The corresponding values for the identical Apollo 15 camera are 10° elevation and 276° azimuth; for Apollo 16, zero elevation and 100° azimuth. Originally, it was intended to strap one Hasselblad electric data camera to the tool pallet in the back of the LRV; however, because time was short, the commander placed it in his seat as vertically as possible. No photograph showing its precise position is available.

CONCLUDING REMARKS

Completion of the preflight photodocumentation of selected Apollo 17 flight articles that were deployed on the lunar surface and of backup units for comparison has established a data base for the potential study of long-term effects of the lunar environment. The inclusion of additional documentation in the form of representative parts, materials, and specifications should provide high-quality standards for the performance of future analyses.

Although the conditions under which the photodocumentation was performed were not ideal, consistent application of a simple procedure resulted in photographs that should be adequate for the purpose intended. The use of an archival technique for preservation of the negatives over a period of decades will ensure the fidelity of the photographs for comparison with the Apollo 17 equipment when it is returned by a future flight crew.

Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas, February 13, 1974
953-36-00-00-72

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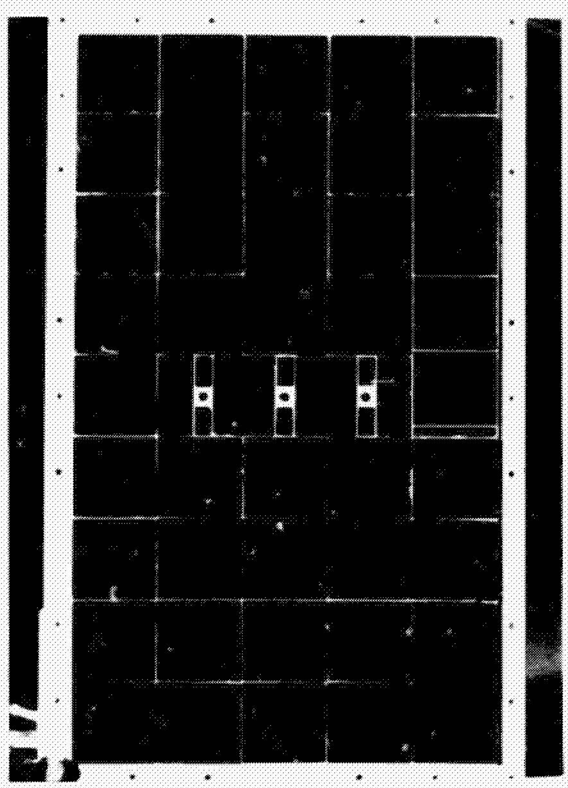
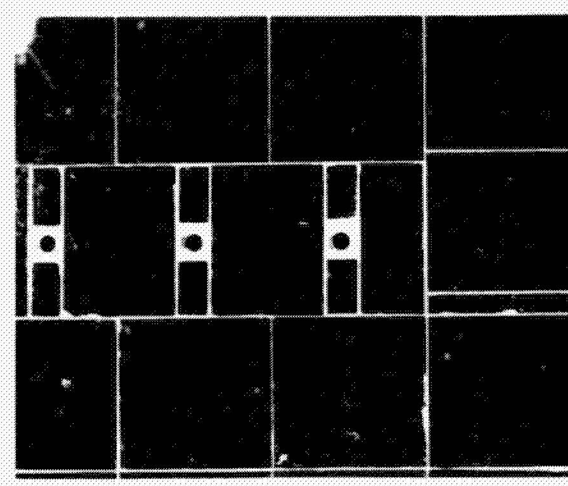
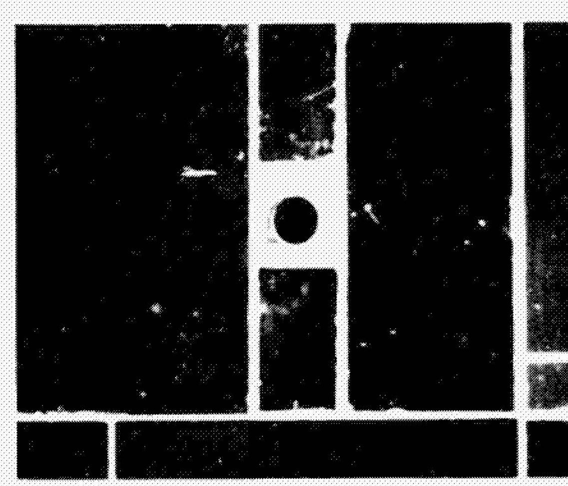


(a) Overall view; CTV, F, T.

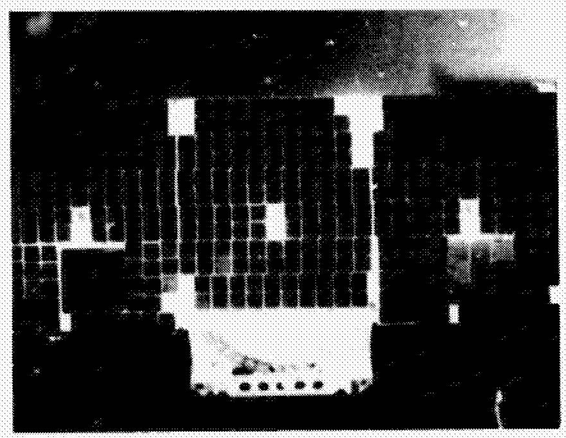


(b) Magnification ≈1:1; CTV, F, T_5.

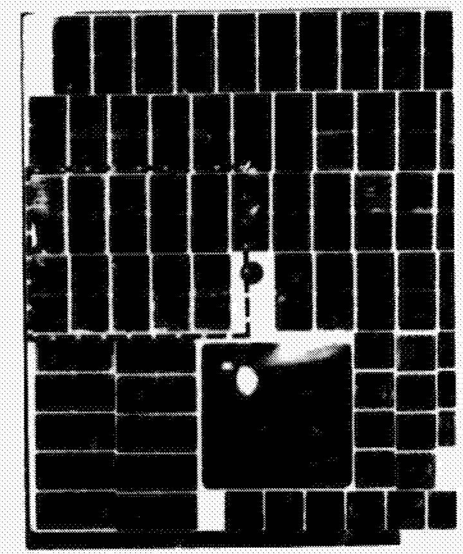


(c) Magnification ≈1:2; CTV, F, T_v.

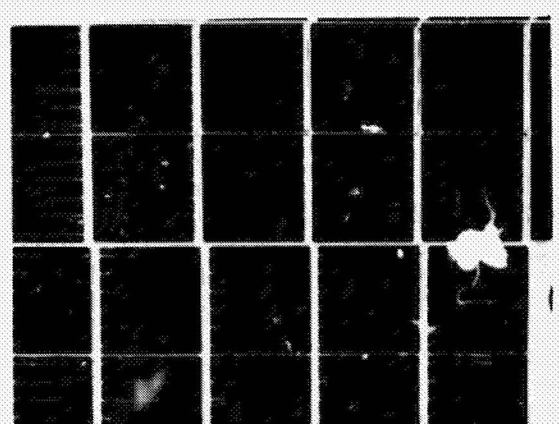
Figure 1. - Mirror surface (color television (CTV) camera top mirror). The imperfections visible are dust grains adhering to the surface (NASA S-73-24695).



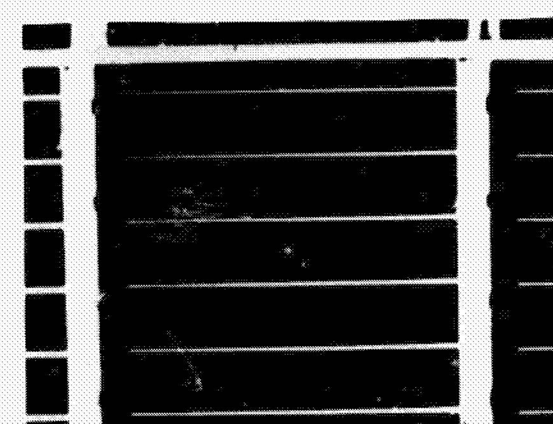
(a) Overall view; SEP, F, X.



(b) Left panel; SEP, F, X_1.

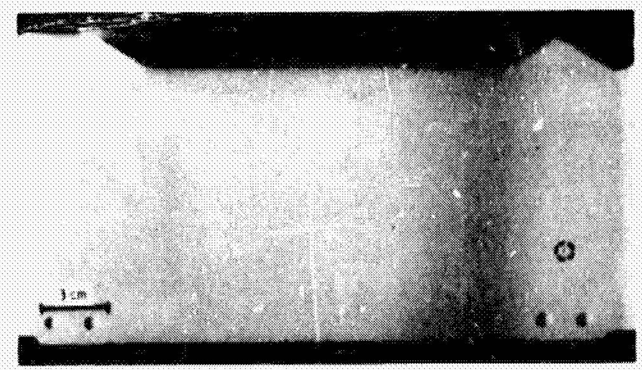


(c) Magnification ≈1:1; SEP, F, X_{12}.



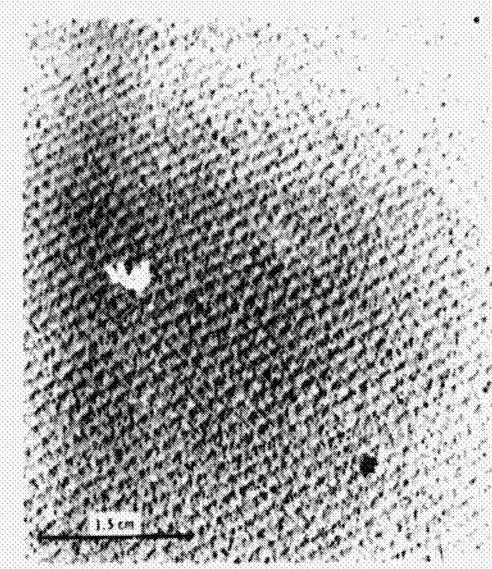
(d) Magnification ≈1:3.5; SEP, F, X_b.

Figure 2. - Glass surface (surface electrical properties (SEP) experiment transmitter solar-cell array) (NASA S-73-24702).



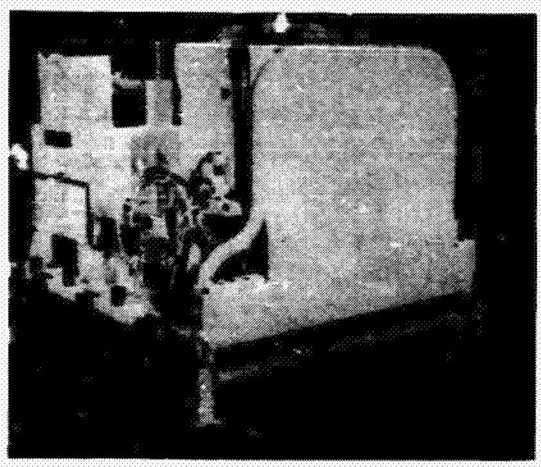
(a) Overall view; LACE, F, A.

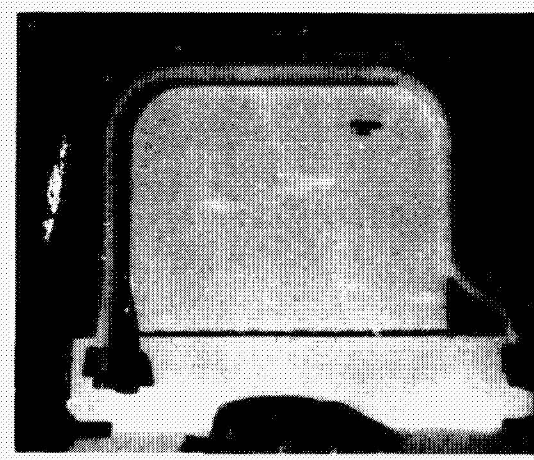
(b) Magnification 1.1; LACE, F, A_1.



(c) Magnification ≈1:2; LACE, F, A_c.

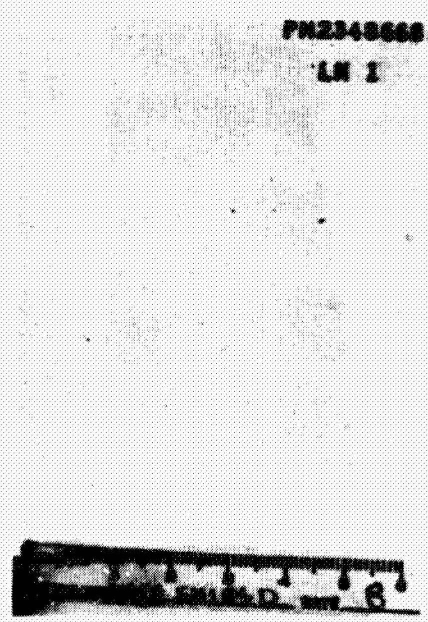
Figure 3. - Glass-fiber cloth coated with thermal paint (lunar atmospheric composition experiment (LACE)) (NASA S-73-24698).

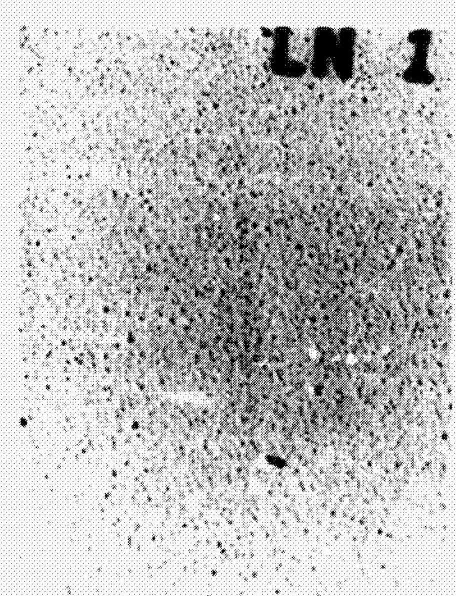




(a) Position on ALSEP subpackage.

(b) Overall view; LS, F.





(c) Magnification ≈1:1, LS, F_4.

(d) Magnification ≈1:3; LS, F_d.

Figure 4. - Metal surfaces coated with thermal paint (LACE shield (LS)) (NASA S-73-24703).

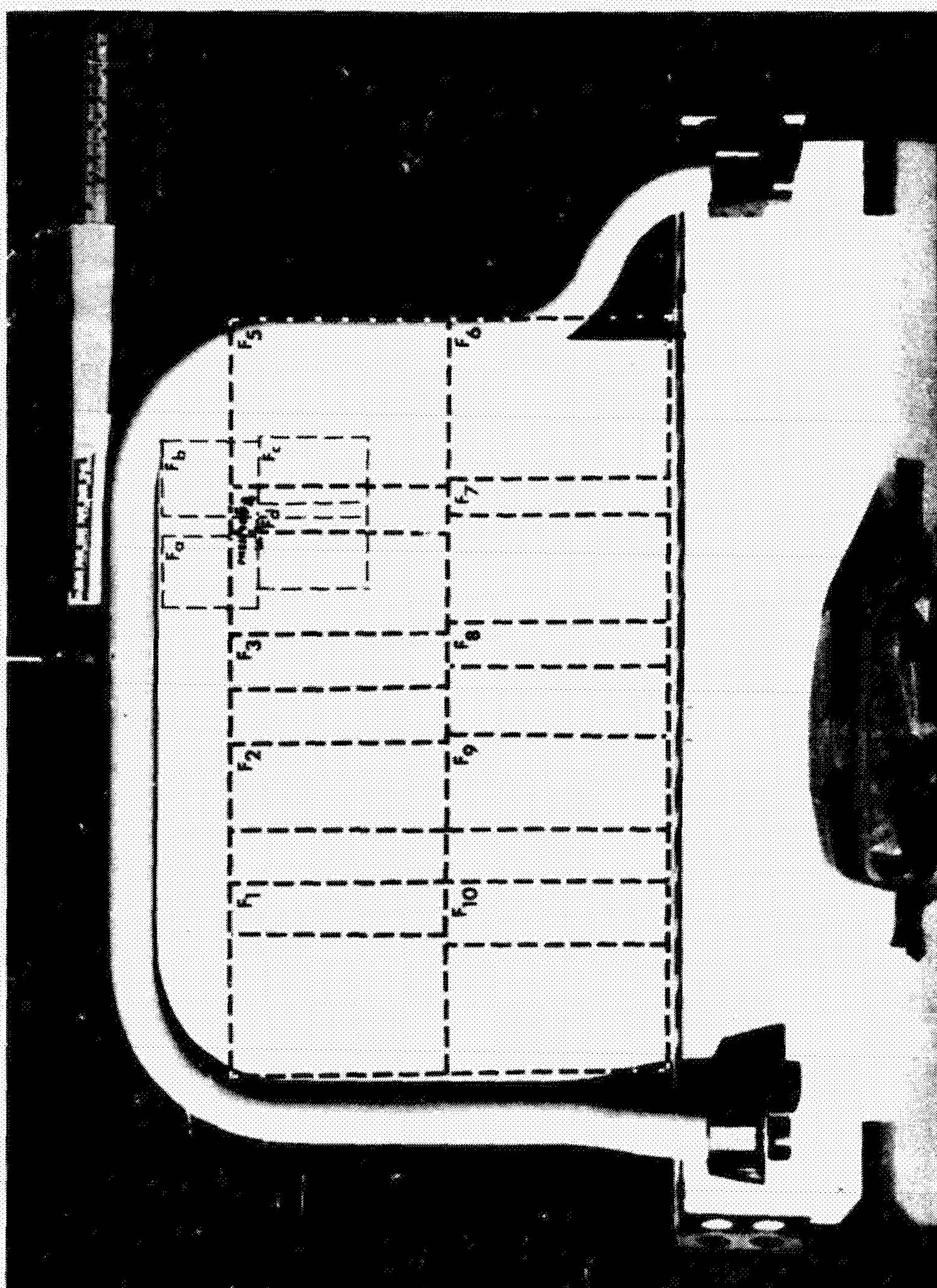
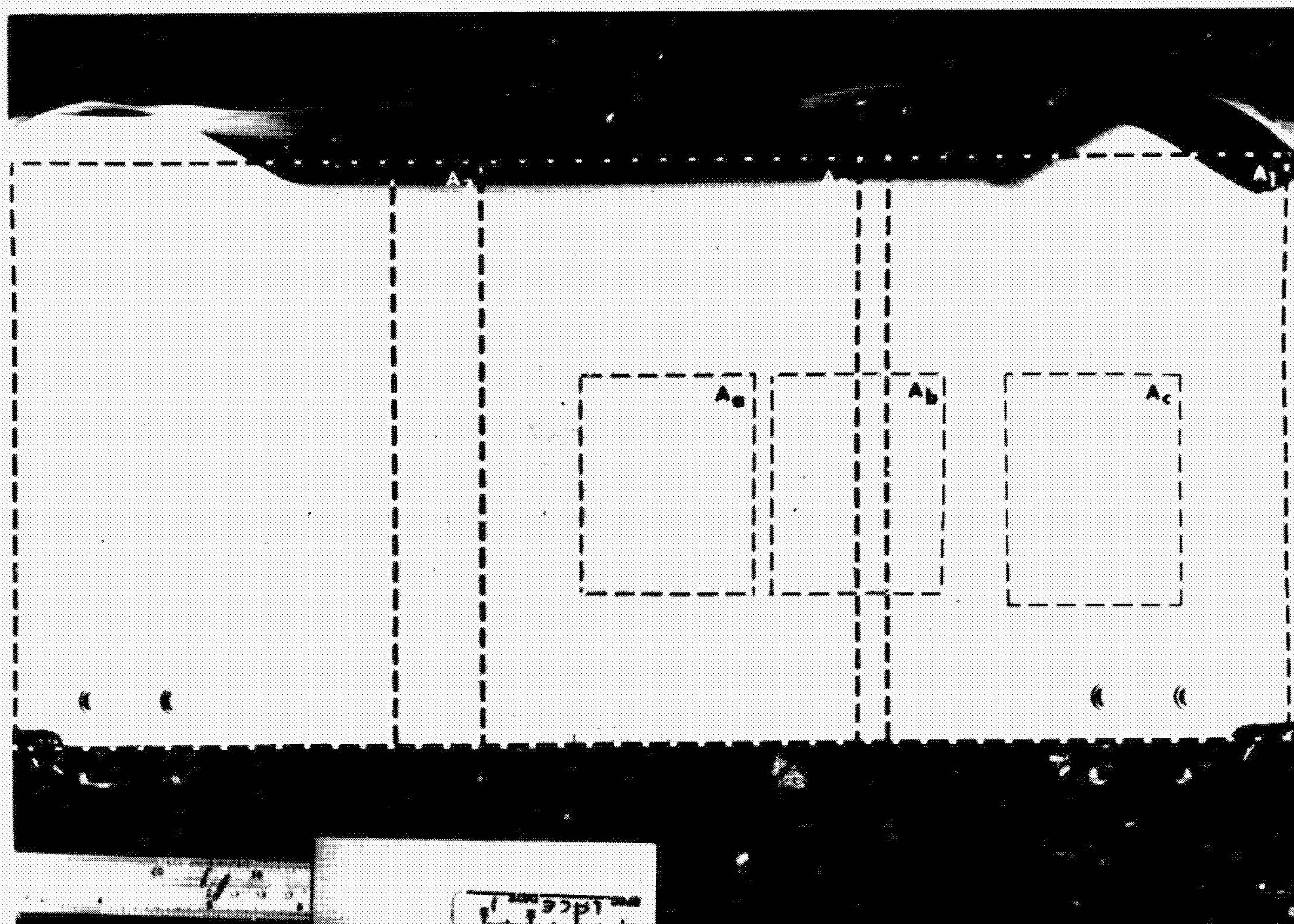


Figure 5. - The LACE protective shield used in ALSEP subpackage, flight unit (LS, F). (See also figs. 4 and 21.) The shield is an aluminum plate coated with thermal protective paint. (Backup unit was not photographed.) Color pictures available: LS, F only (NASA S-73-24694).



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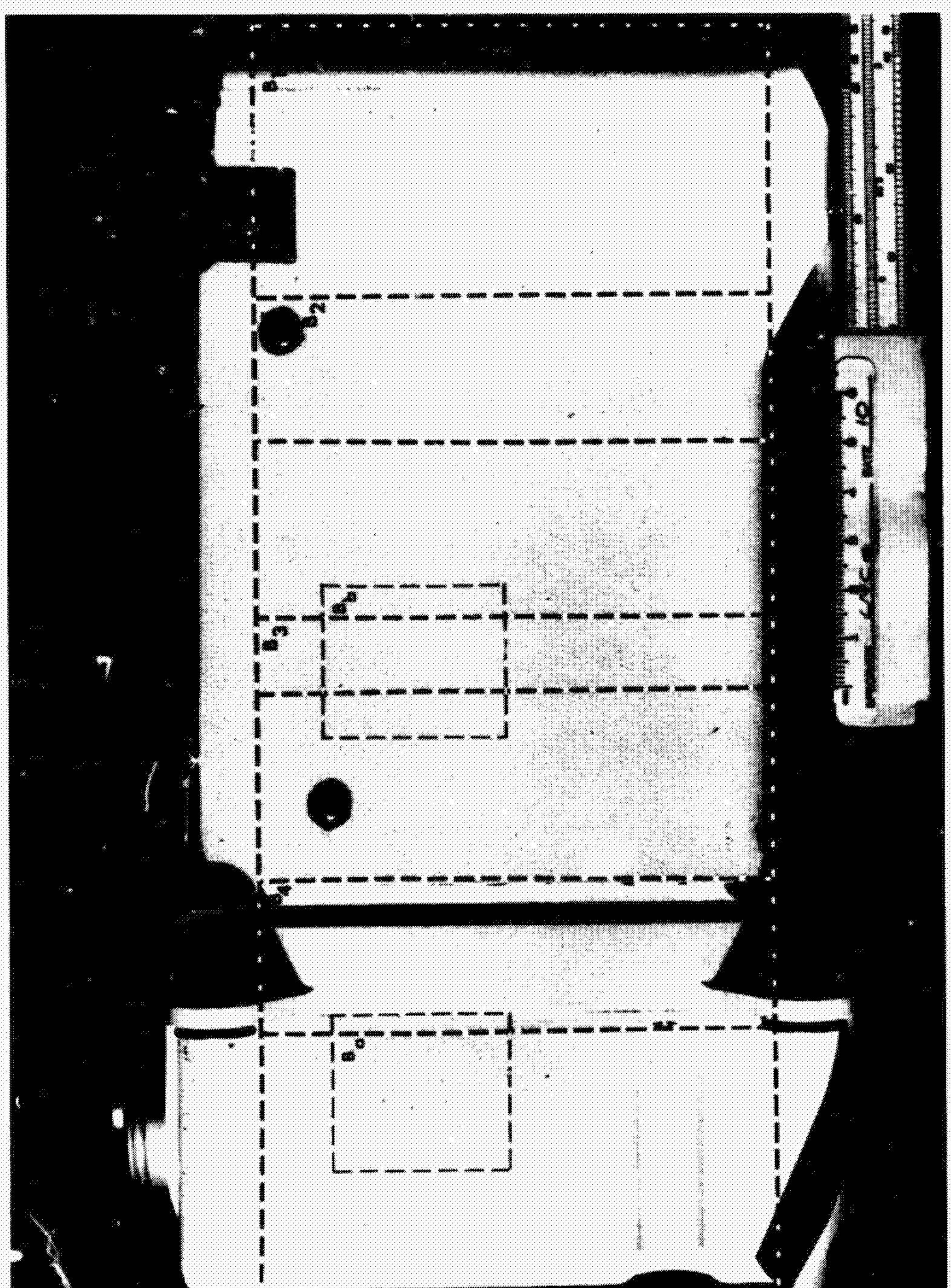
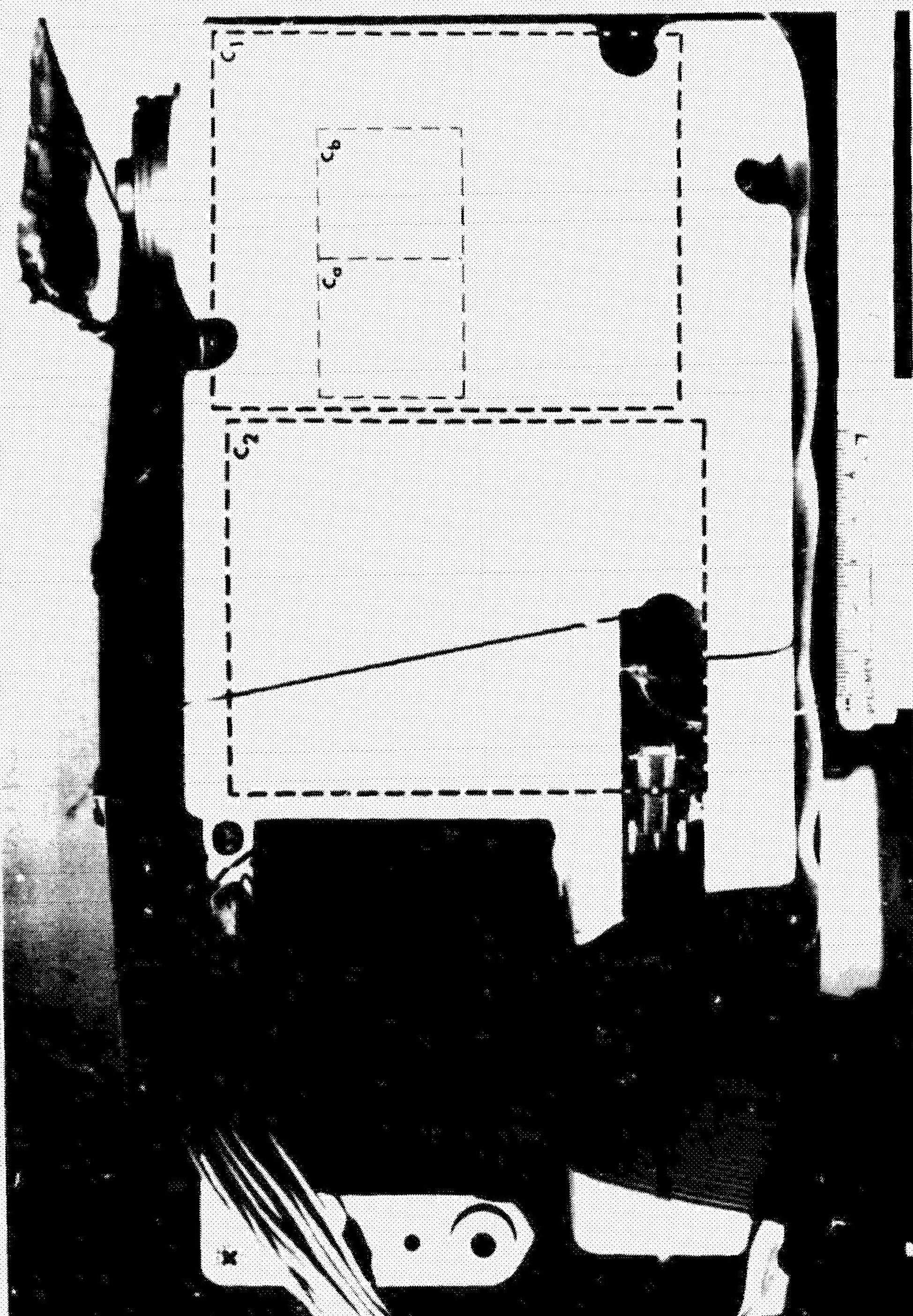
(a) Side A: LACE, F, A (NASA S-73-25917).

Figure 6. - The LACE, flight unit. The LACE is essentially an orthogonal box constructed of glass fiber. (Backup unit was not photographed.) Color pictures available: F,A; F,B; F,C; F,D; F,C_a; and F,C_b.



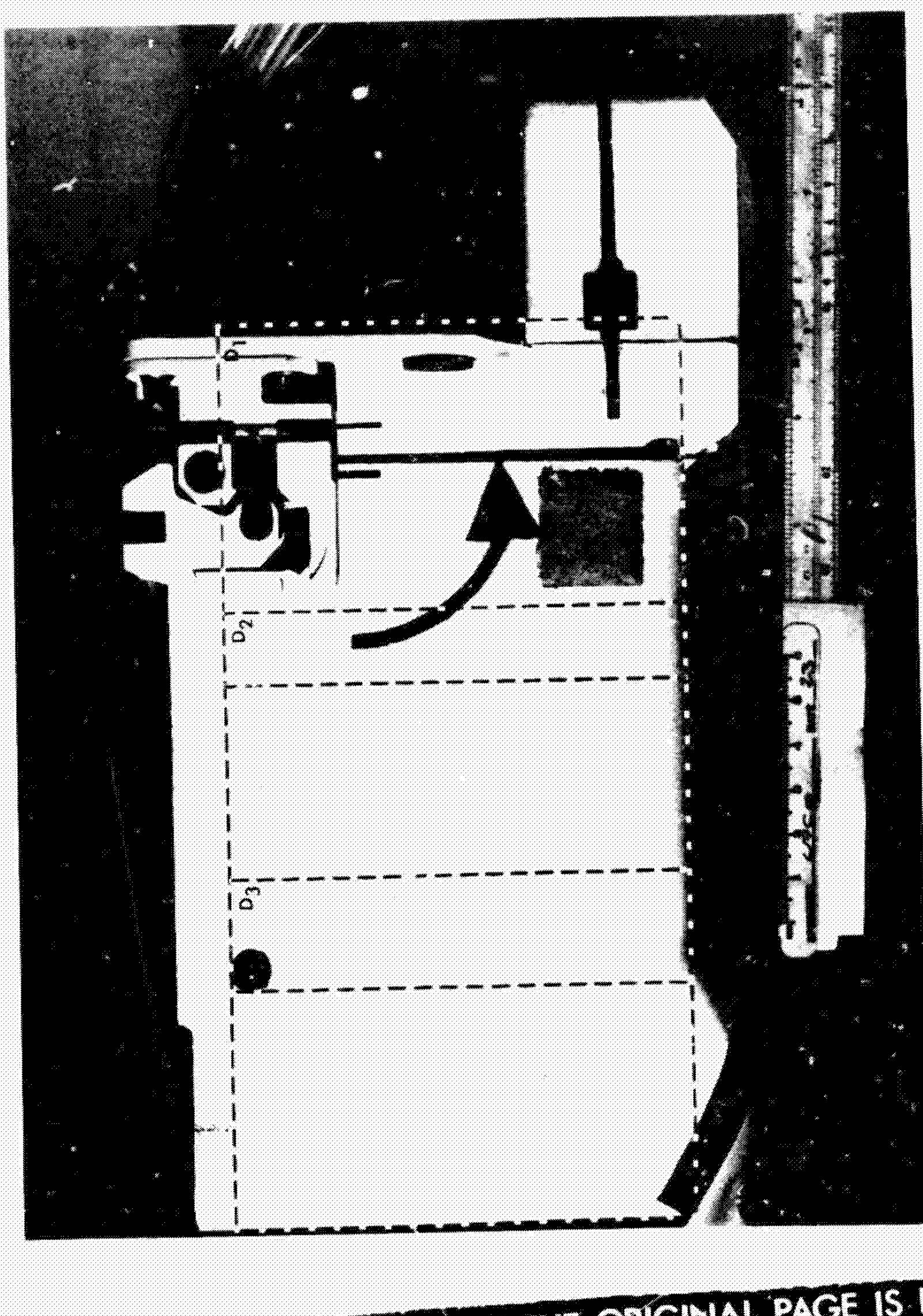
(b) Side B; LACE, F, B (NASA S-73-25924).

Figure 6. - Continued.



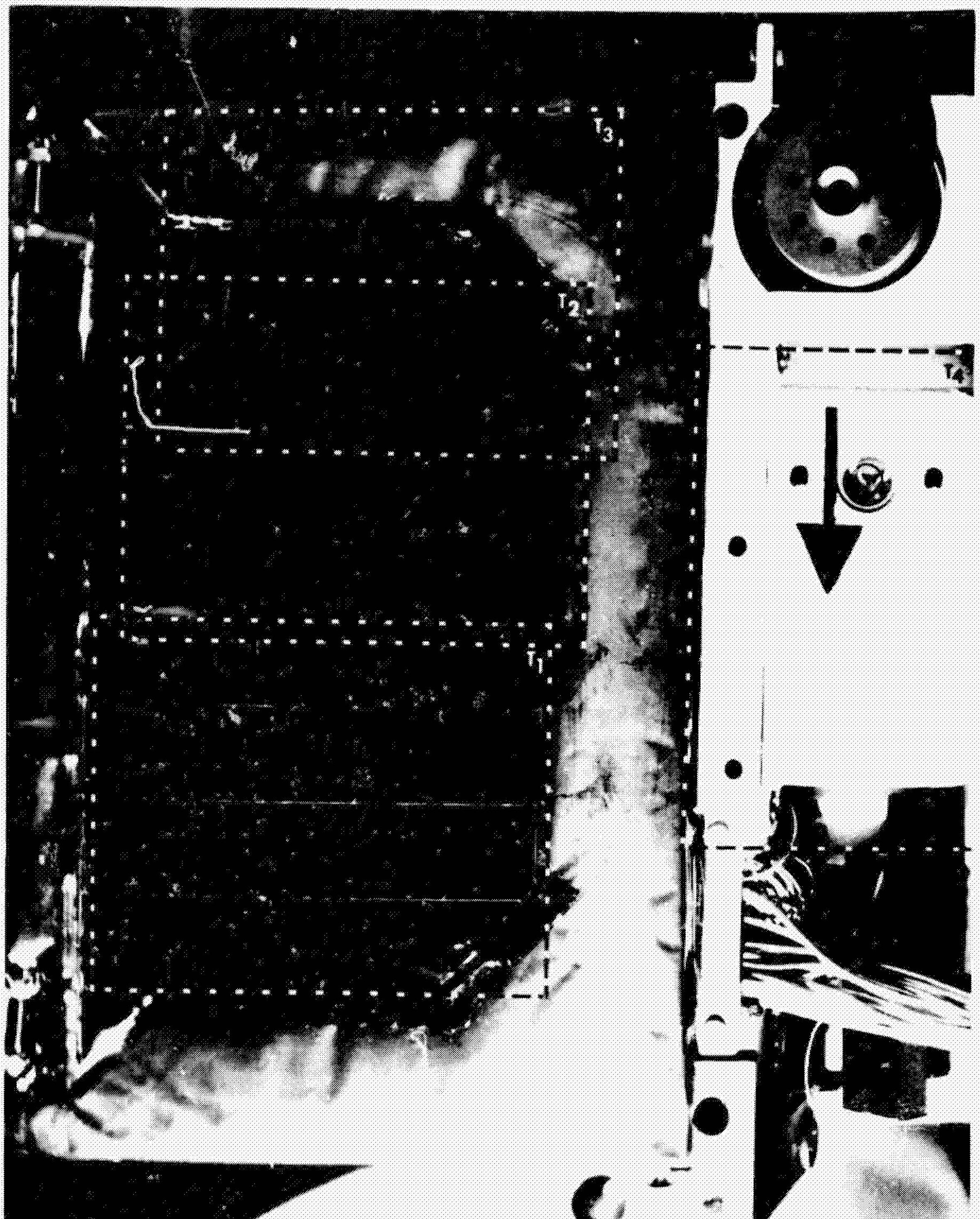
(c) Side C: LACE, F, C (NASA S-73-25919).

Figure 6. - Continued.



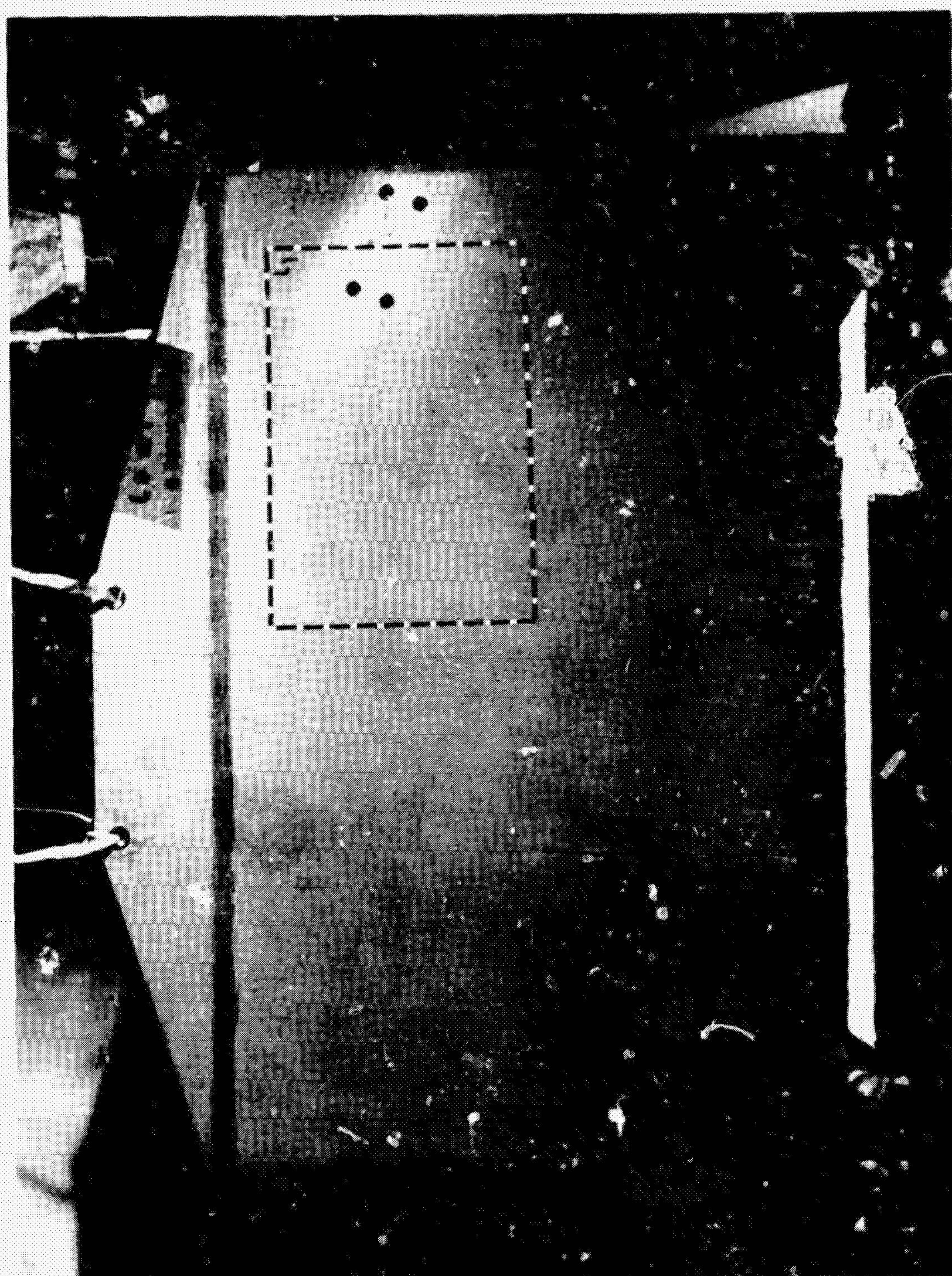
(d) Side D; LACE, F, D (NASA S-73-25922).

Figure 6. - Continued.



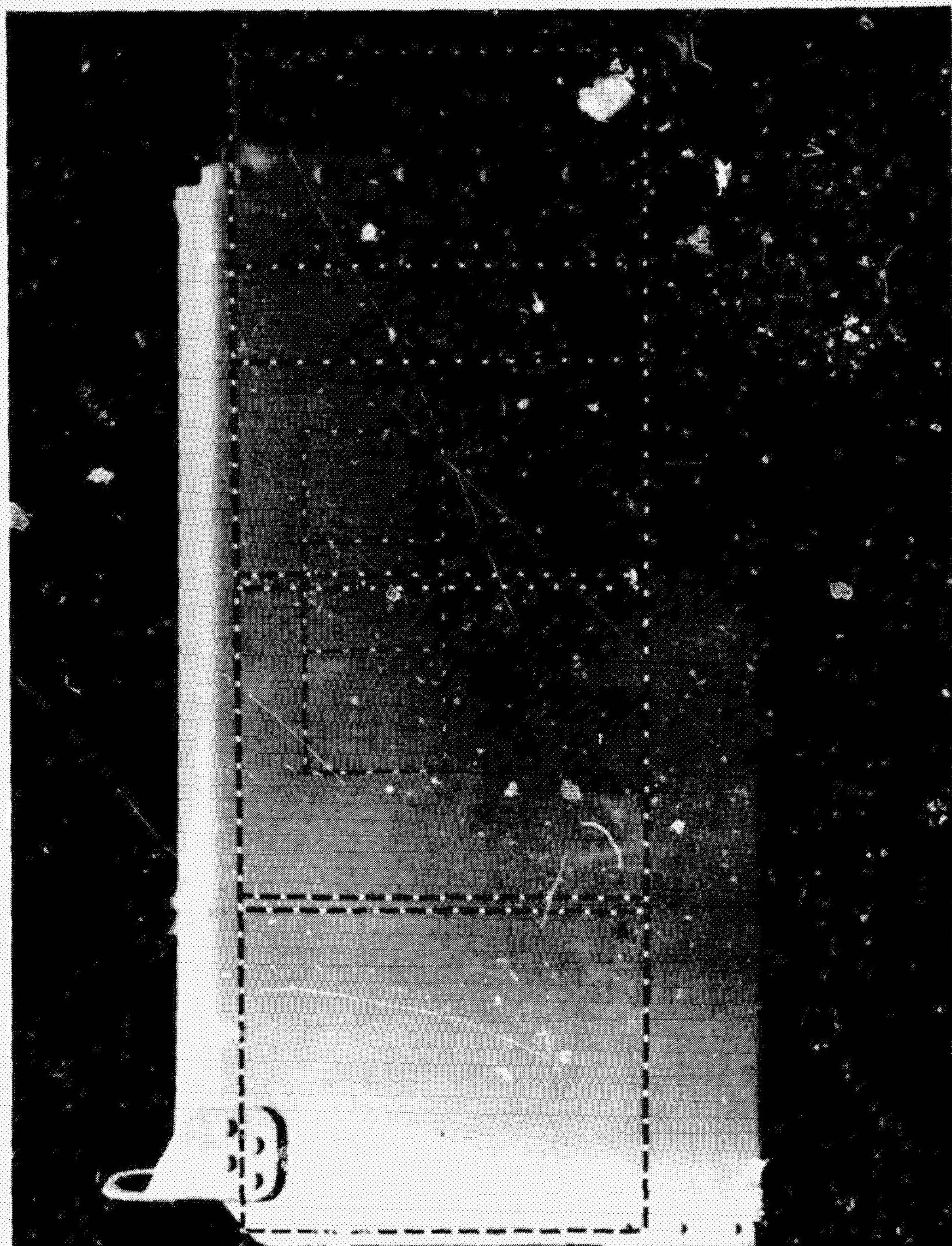
(e) Top side: LACE, F, T (NASA S-73-25910).

Figure 6. - Continued.



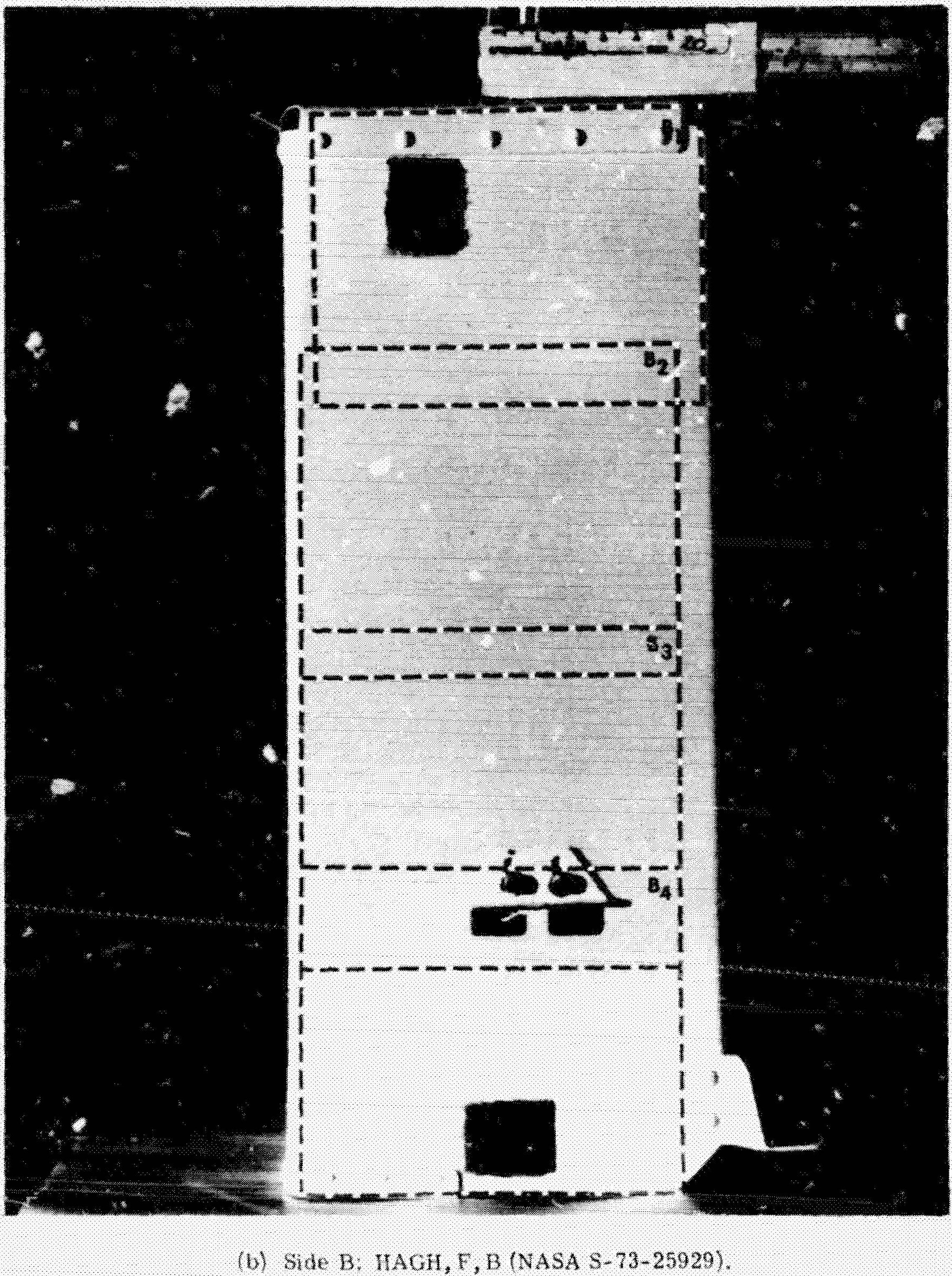
(f) Lid; LACE, F, L (NASA S-72 25921).

Figure 6. - Concluded.



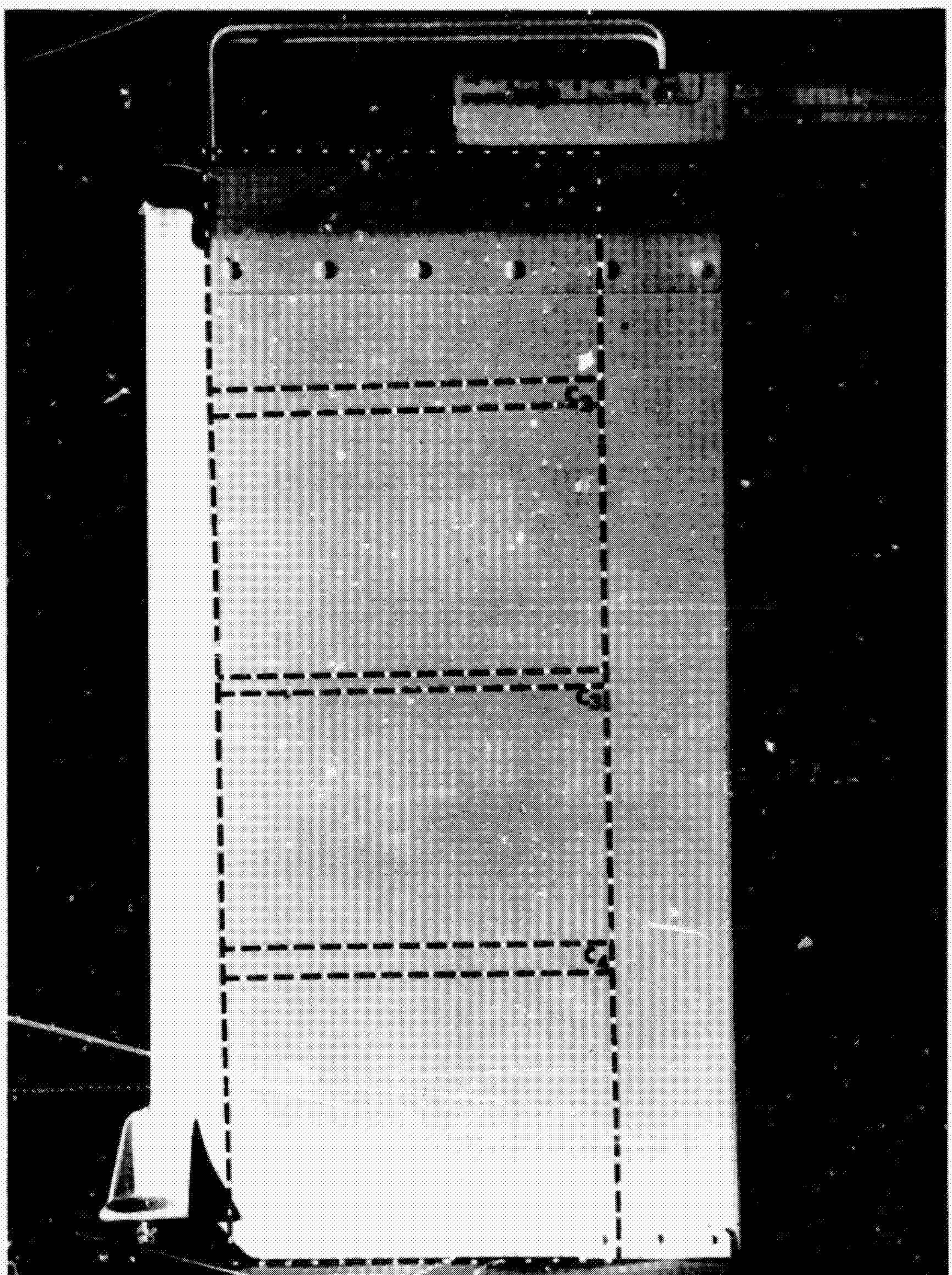
(a) Side A; HAGH, F, A (NASA S-73-24696)

Figure 7. - Helix antenna gimbal housing (HAGH), flight unit. The HAGH is an orthogonal box made of sheet aluminum and coated with thermal protective paint. (Backup unit was not photographed.) Color pictures available: F, A; F, B; F, C; F, D; F, I; and F, A_c.



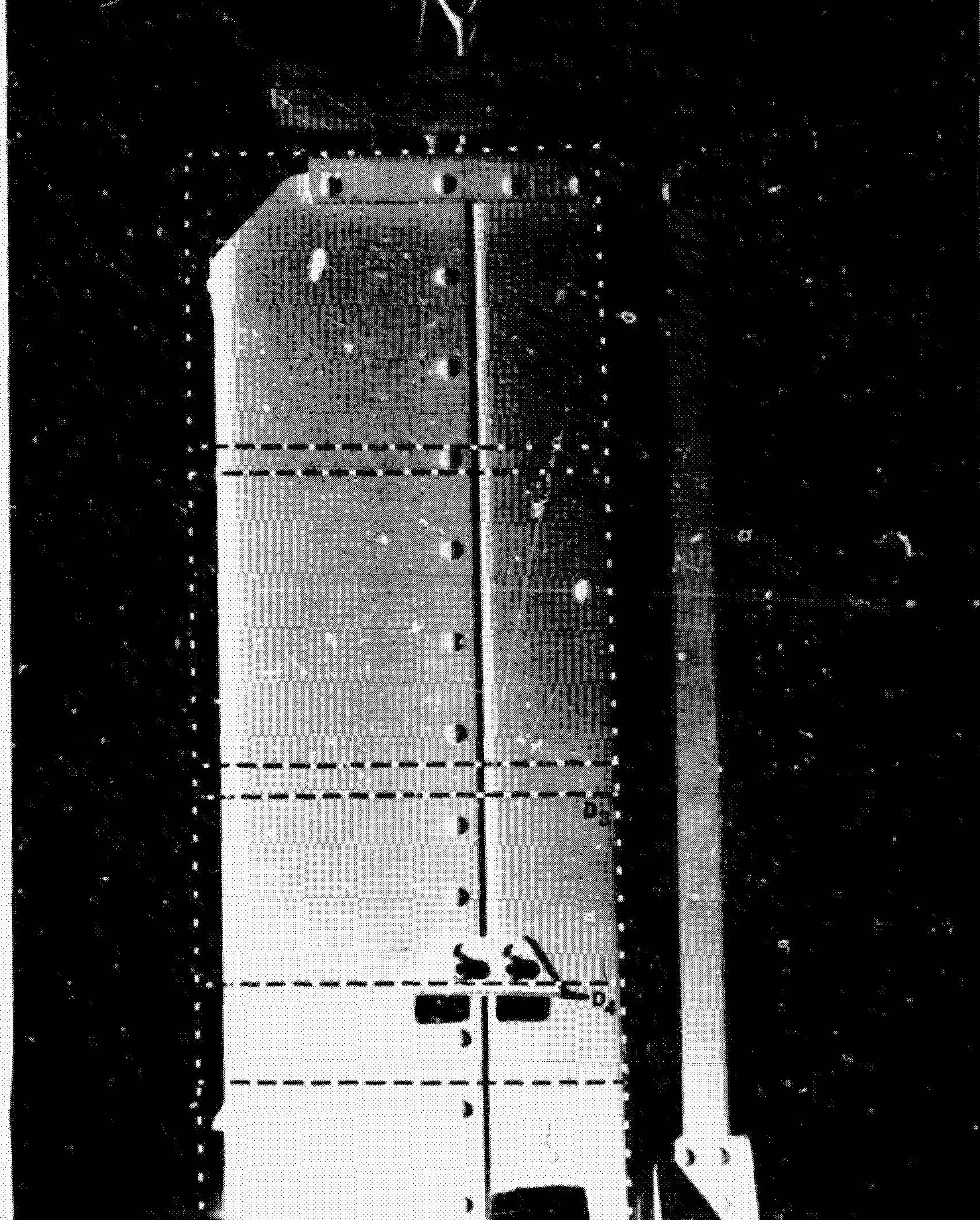
(b) Side B: HAGH, F, B (NASA S-73-25929).

Figure - Continued.



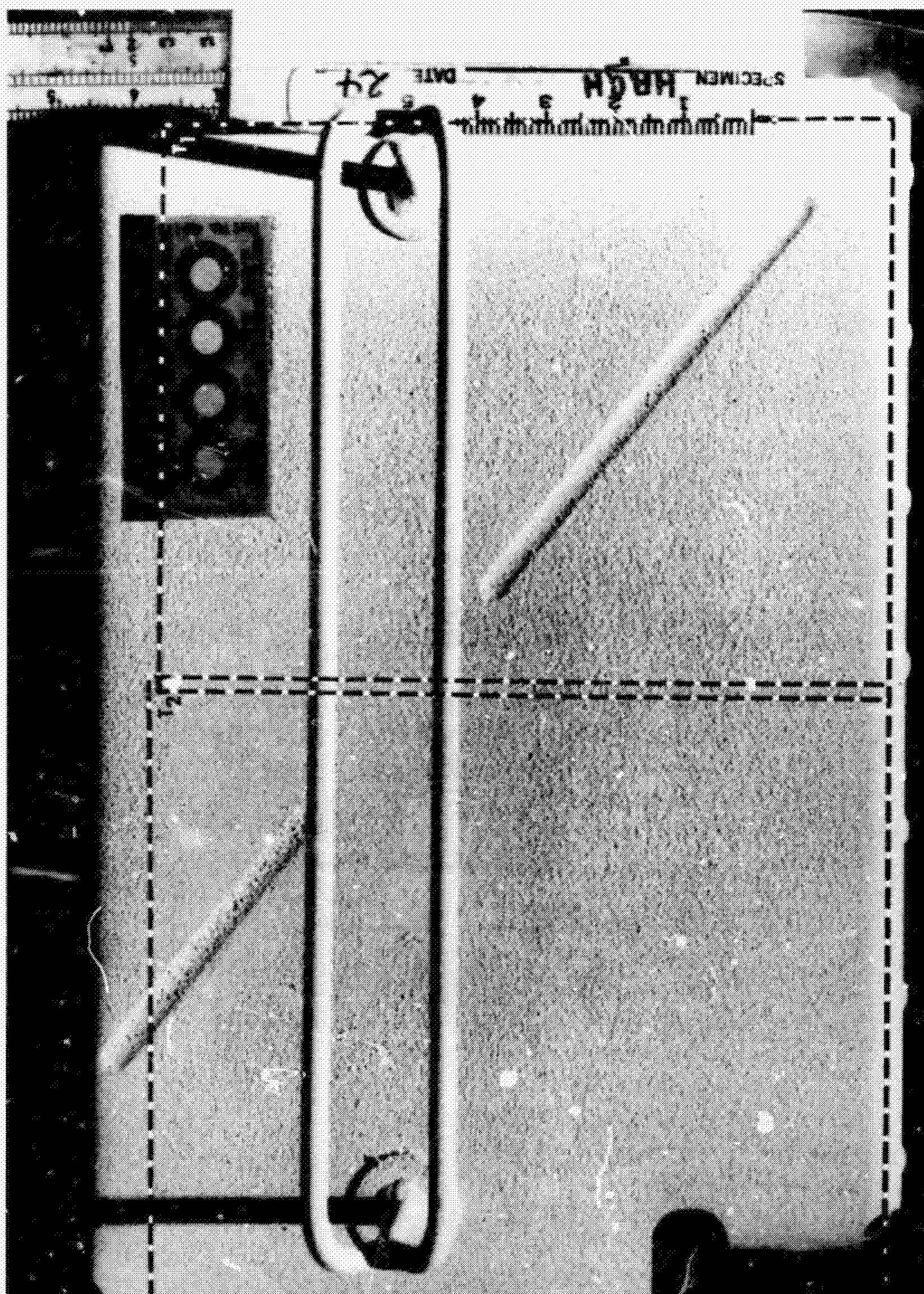
(c) Side C: HAGH, F, C (NASA S-73-25915).

Figure 7. - Continued.



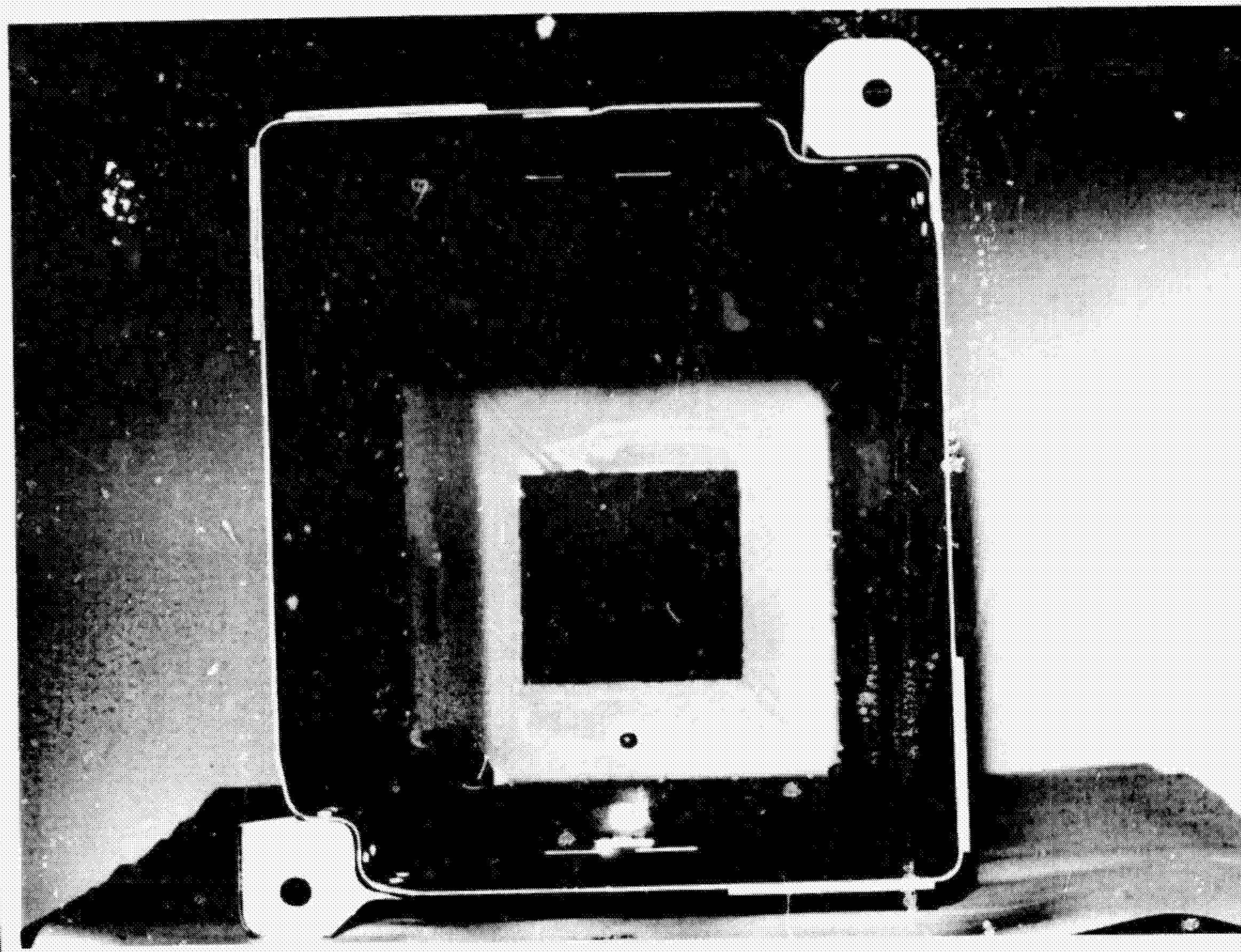
(d) Side D; HAGH, F, D (NASA S-73-25914).

Figure 7.- Continued.



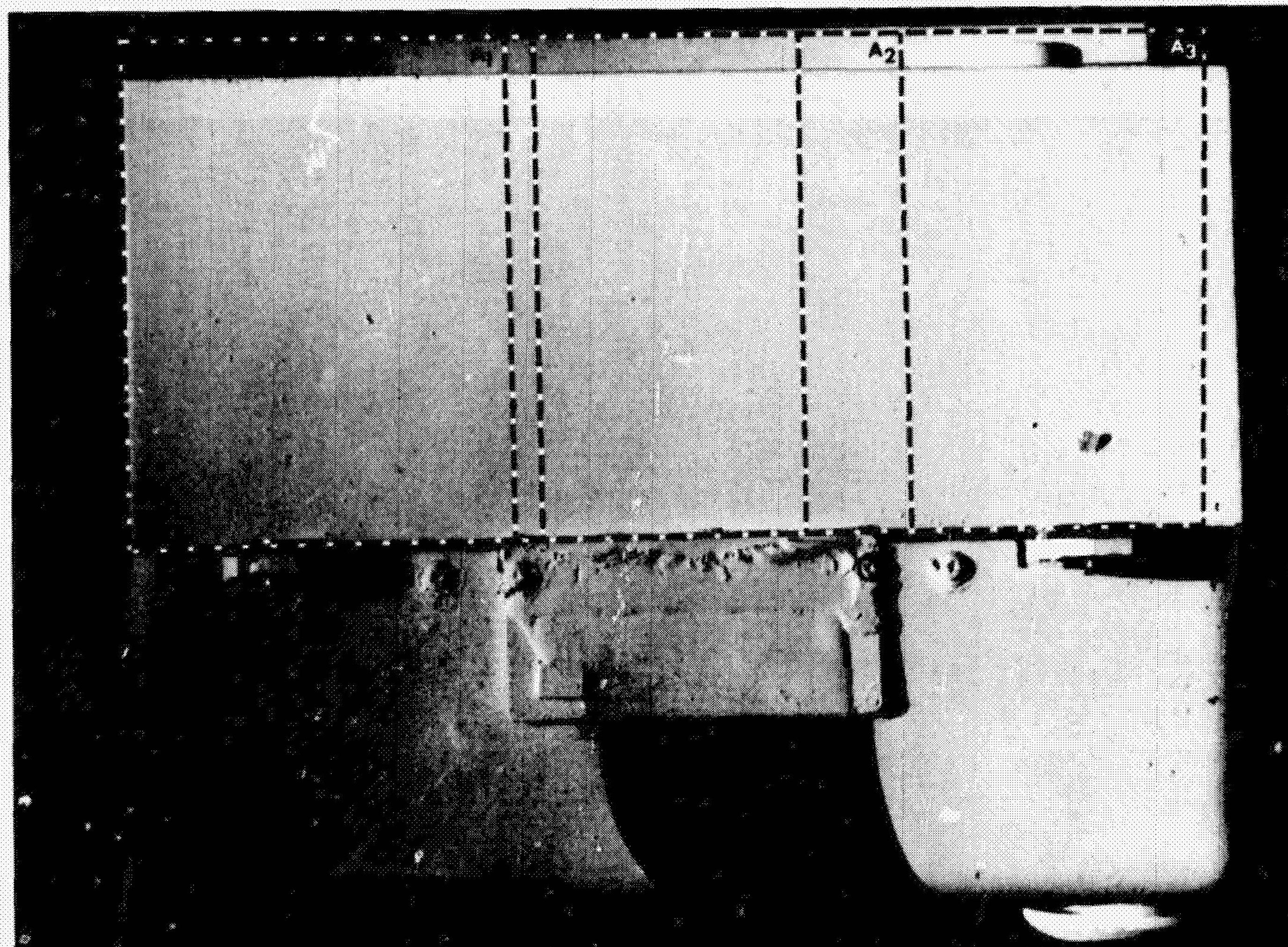
(e) Top side; HACH, F, T (NASA S-73-25925).

Figure 7. - Continued.



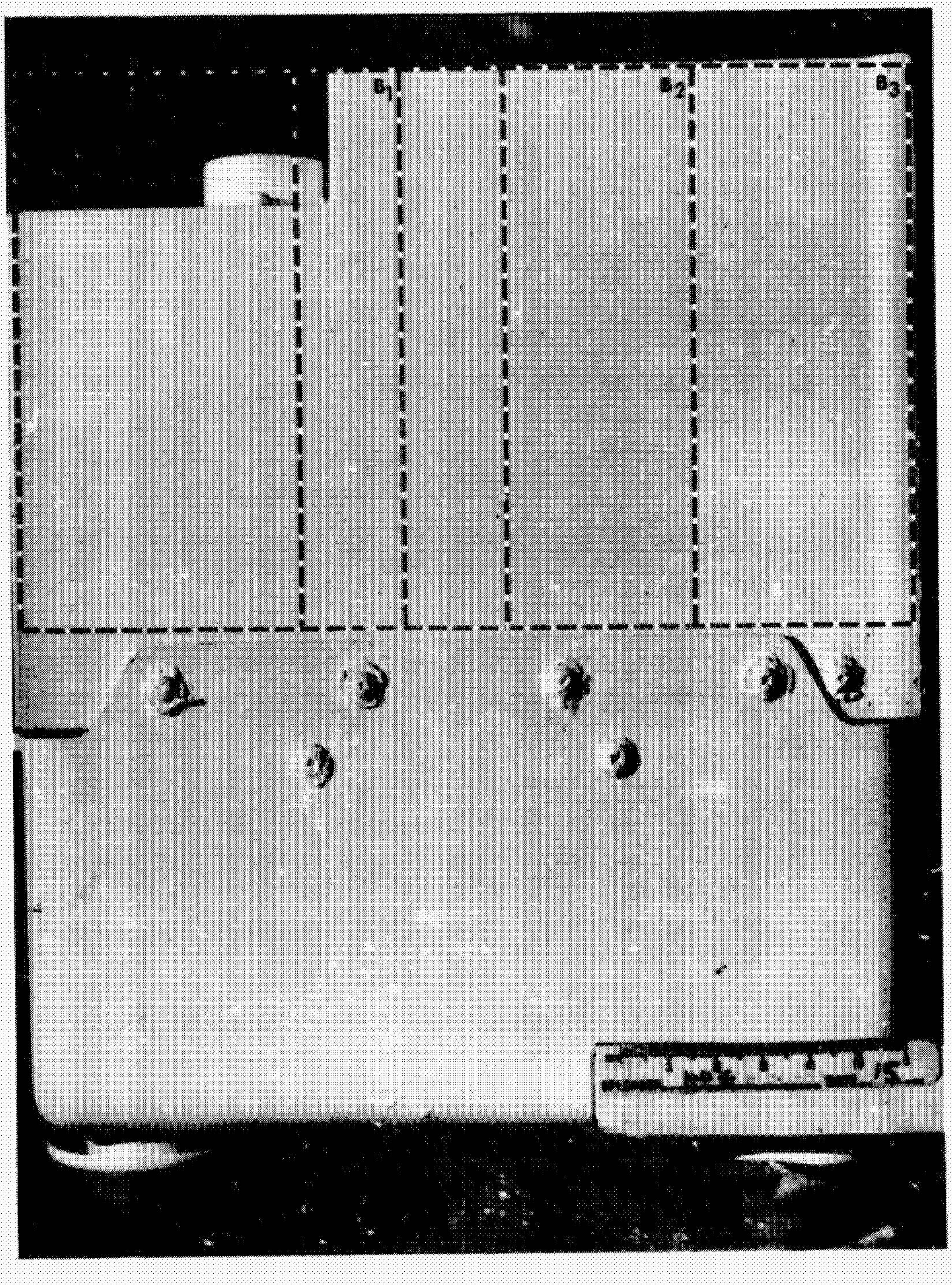
(f) Interior; HAGH, F, I (NASA S-73-25928).

Figure 7. - Concluded.



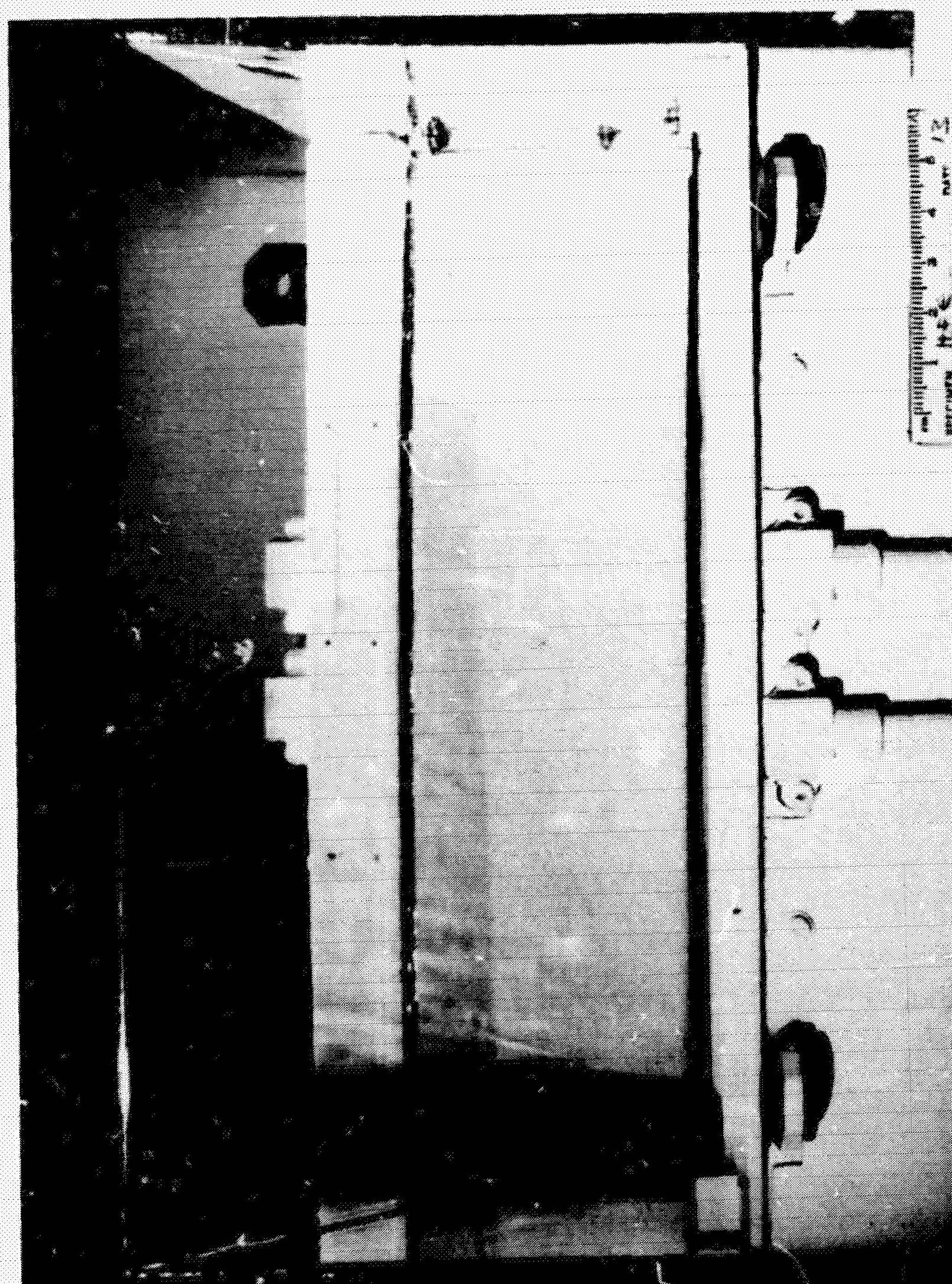
(a) Side A; HFE, F, A (NASA S-73-25908).

Figure 8. - Heat flow experiment (HFE) electronics box, flight unit. The HFE electronics box is an orthogonal box made of glass fiber coated with thermal protective paint. (Backup unit was not photographed.) Color pictures available: F, A; F, B; F, C; F, D; and F, T.



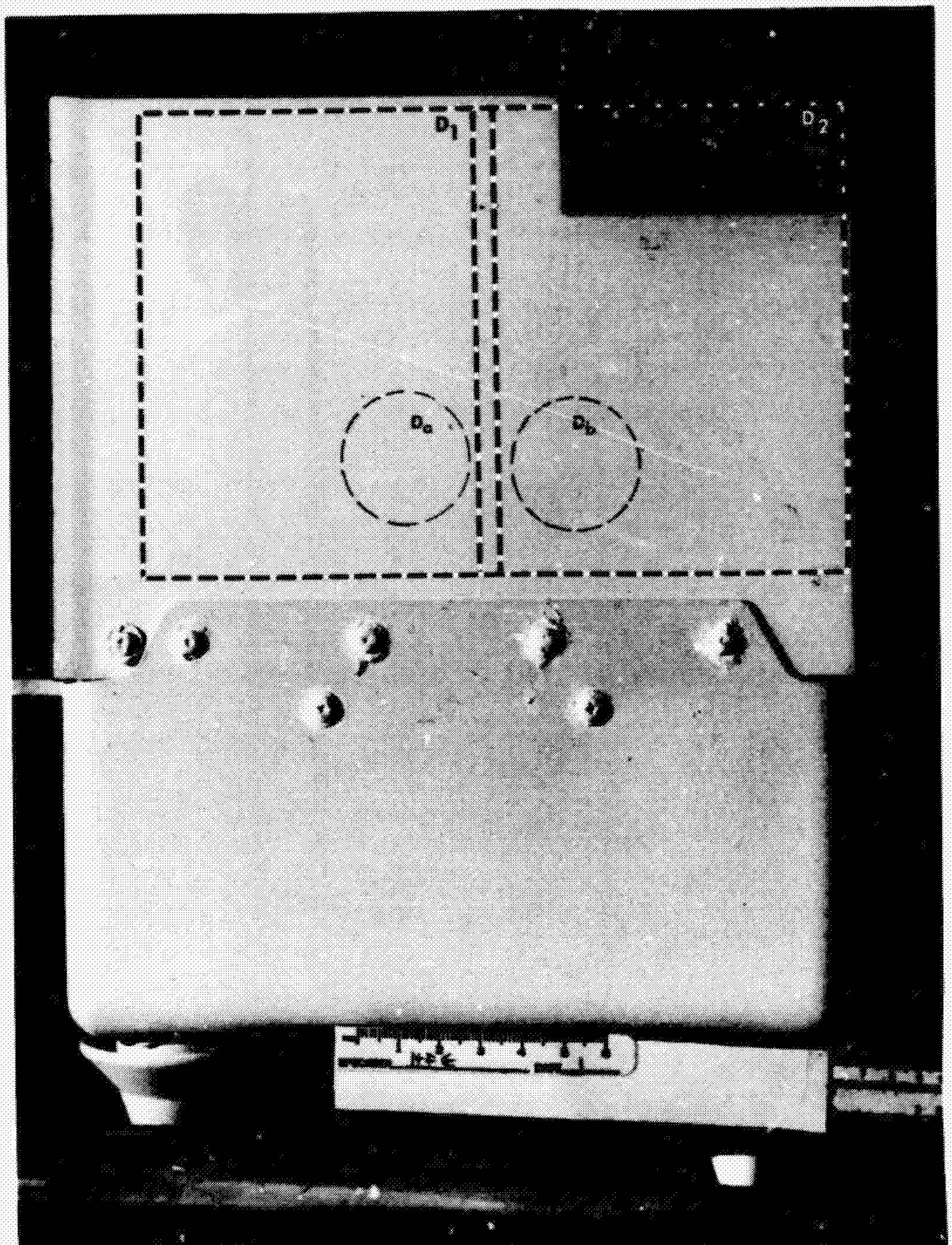
(b) Side B; HFE, F, B (NASA S-73-25906).

Figure 8. - Continued.



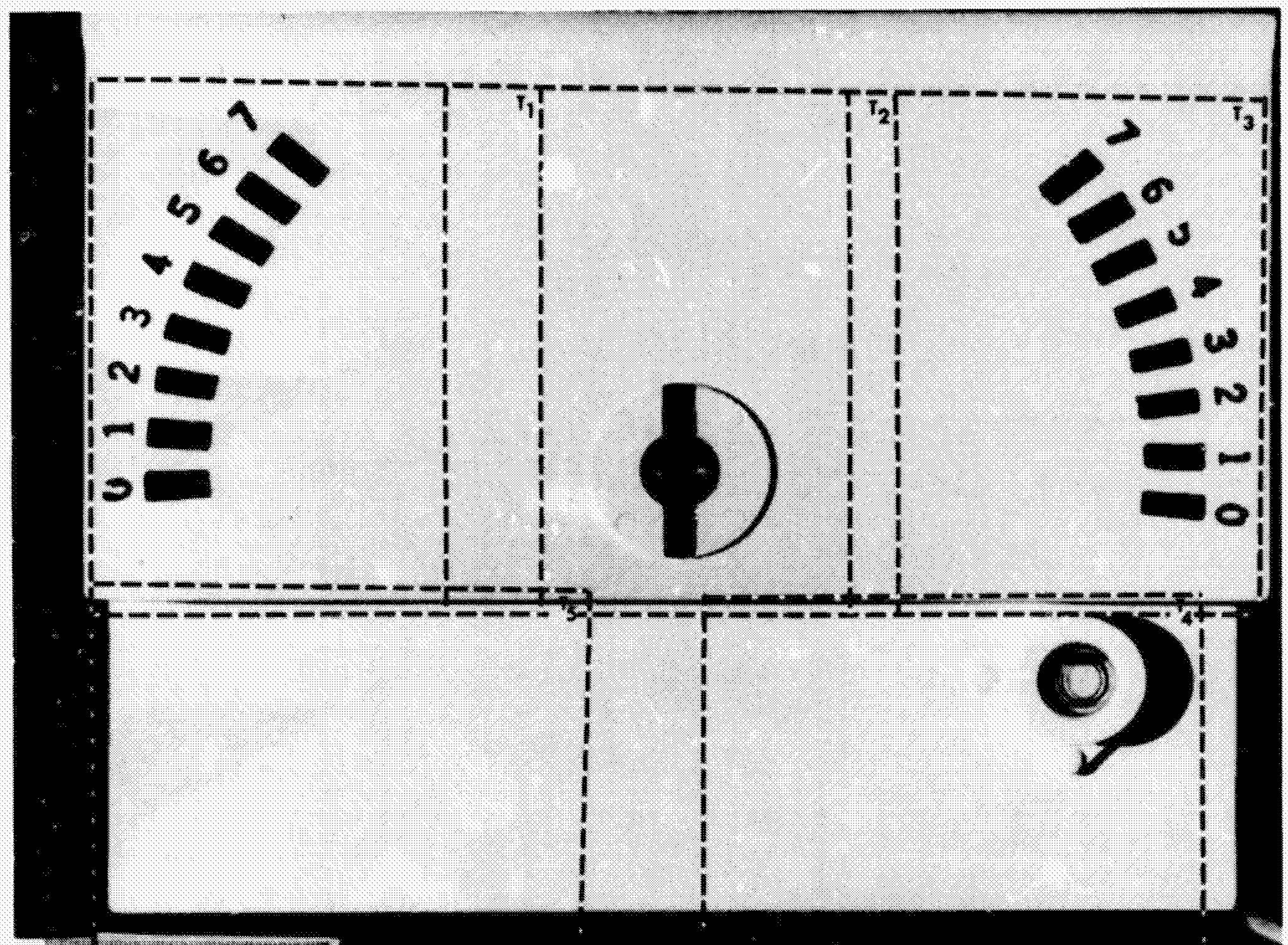
(c) Side C; HFE, F, C (NASA S-73-25907).

Figure 8. - Continued.



(d) Side D; HFE, F, D (NASA S-73-25909).

Figure 8. - Continued.



(e) Top side; HFE, F, T (NASA S-73-25926).

Figure 8. - Concluded.

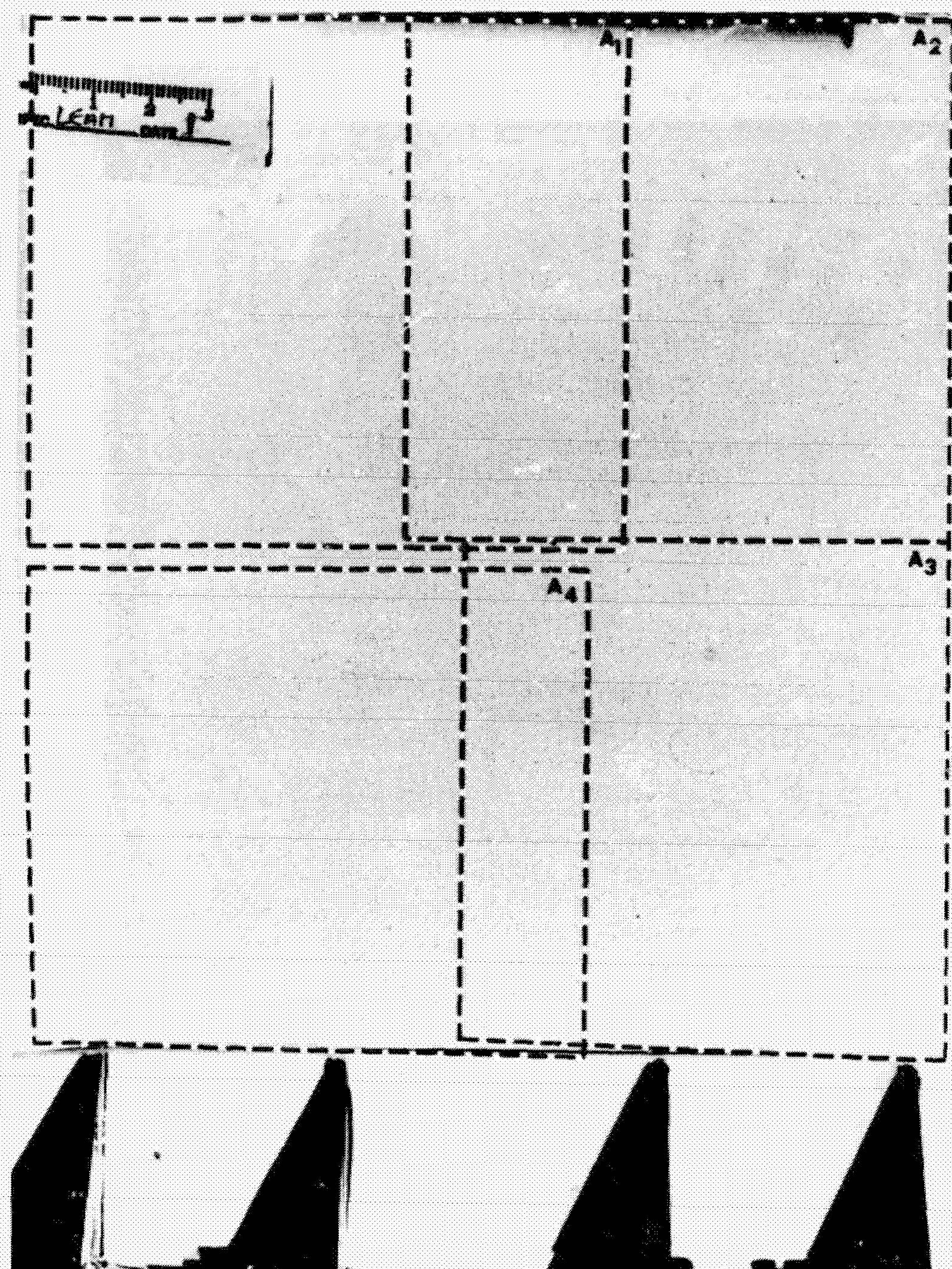


Figure 9. - Lunar ejecta and meteorites (LEAM) experiment, flight unit, side A (LEAM, F, A). The LEAM is contained in a glass-fiber box coated with thermal protective paint. Sides B, C, D, and top (T) were also photographed, but no closeup photography (at 1:1 magnification) was undertaken. Color pictures available: F, A; F, B; F, D; F, A_1; F, A_2; F, A_3; and F, A_4 (NASA S-73-25920).

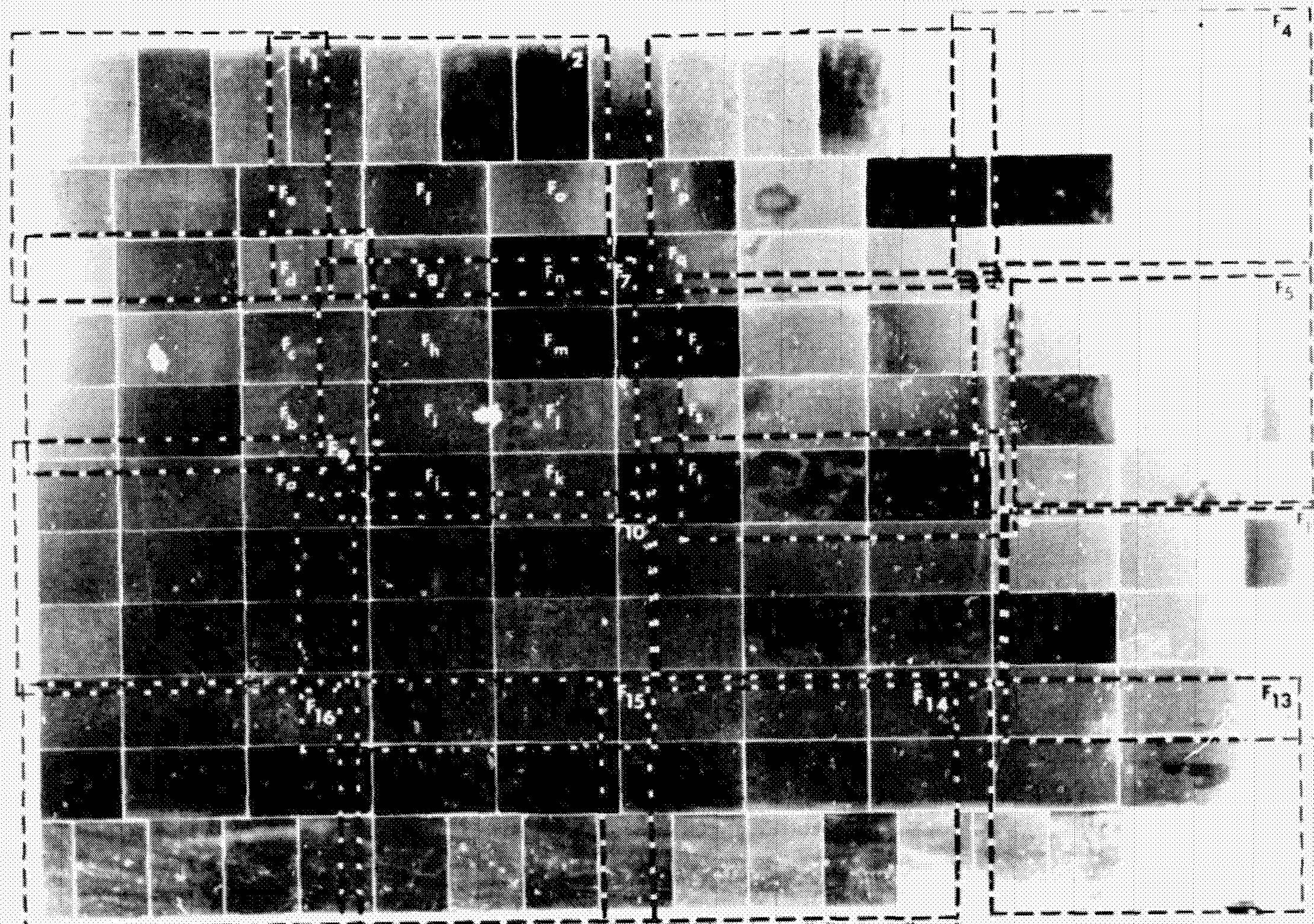


Figure 10. - Lunar communications relay unit (LCRU), flight unit (LCRU, F). The LCRU was the largest mirror surface documented; individual mirror elements are approximately 2 by 5 centimeters. Note extensive closeup photography at ≈1:2.5 magnification (F_a to F_t). For clarity, only subscripts are given for location without detailed outline of frames. Color pictures available: F and F_{16} (NASA S-73-24691).

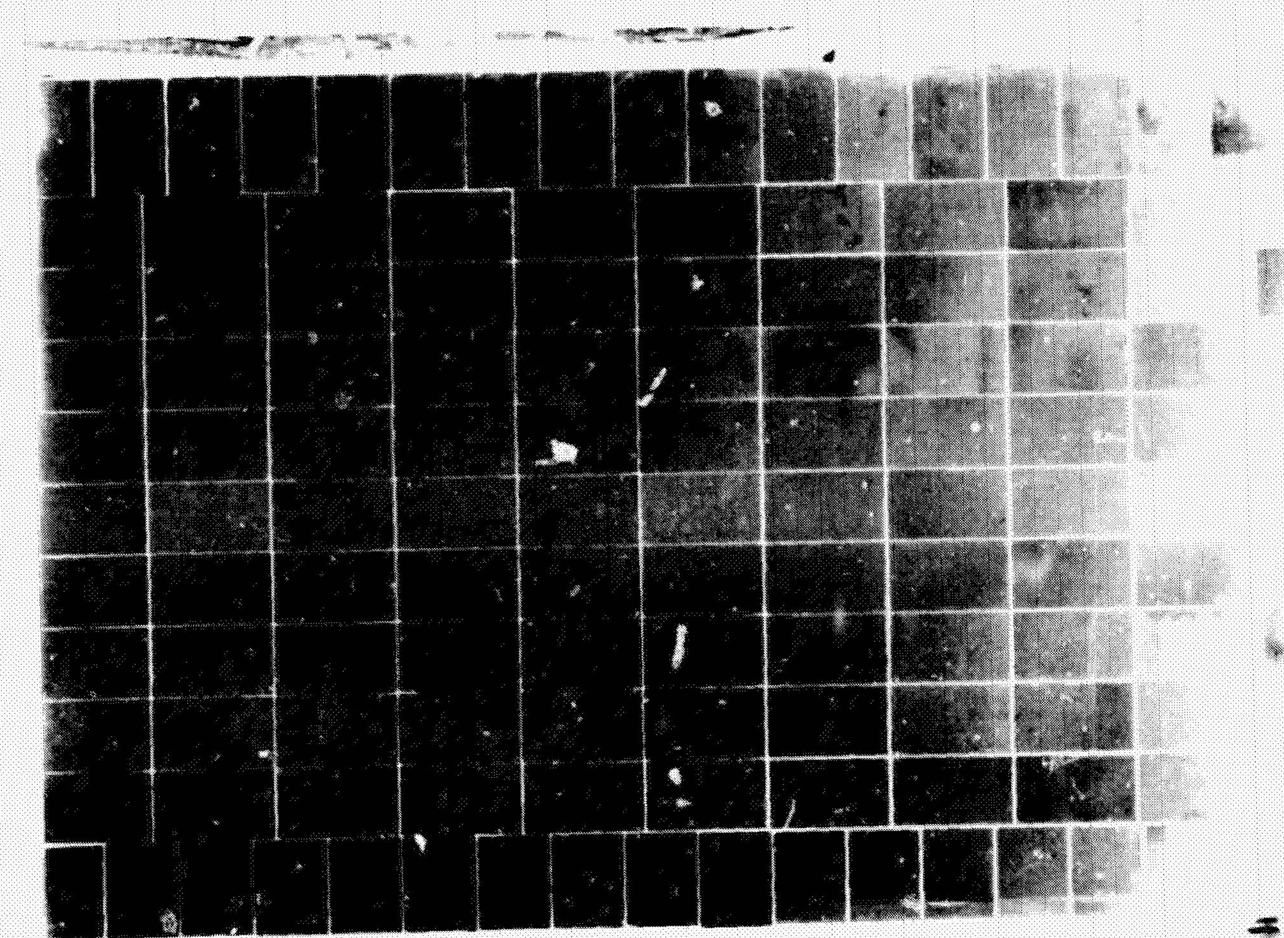


Figure 11. - The LCRU, backup unit (LCRU, B). Photographic coverage and labeling of frames are identical to those of the flight unit (fig. 10) (NASA S-73-25905).

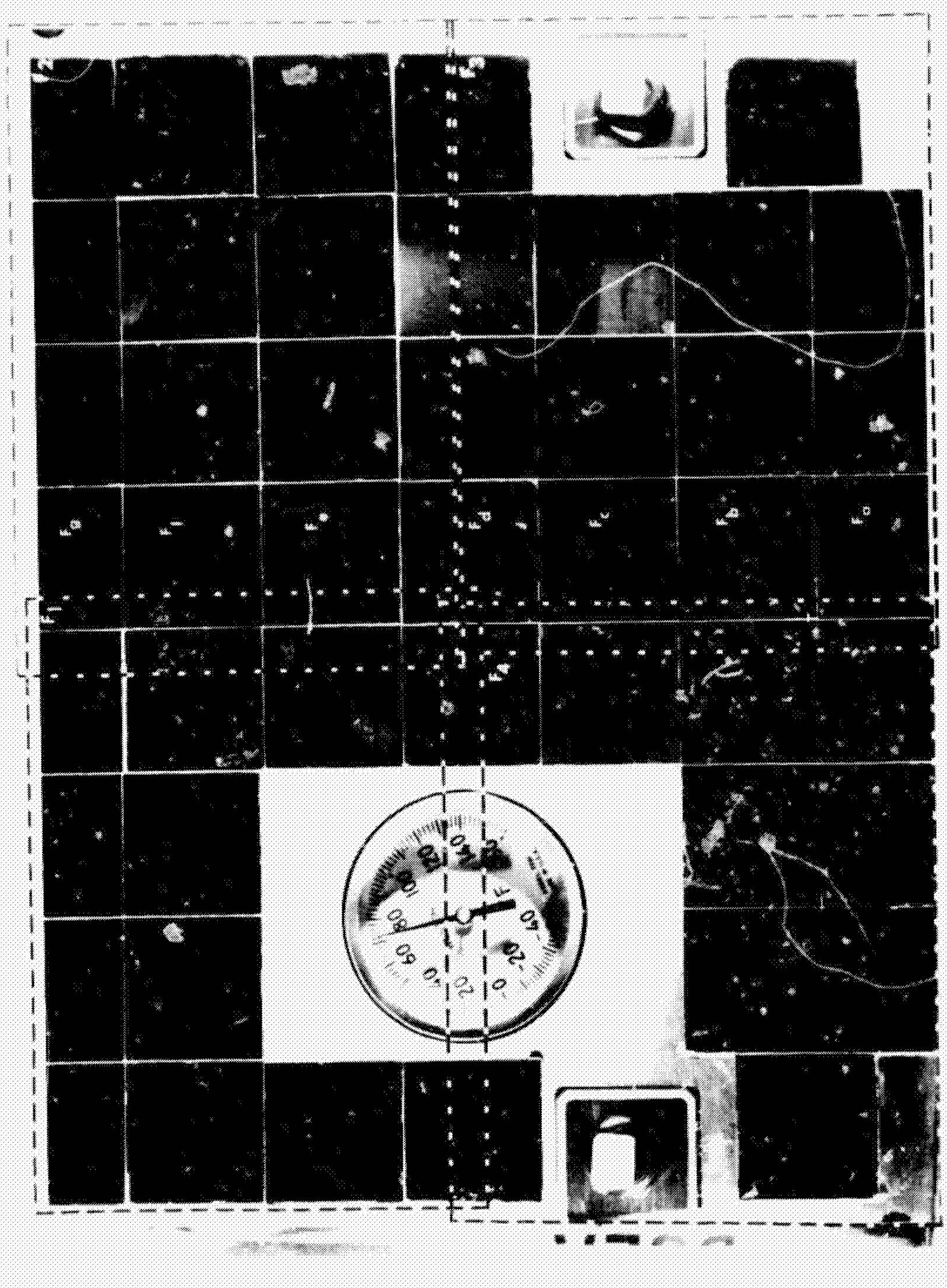


Figure 12. - The SEP experiment receiver, flight unit (SEP-R, F), top mirror. Color picture available (NASA S-73-25918).

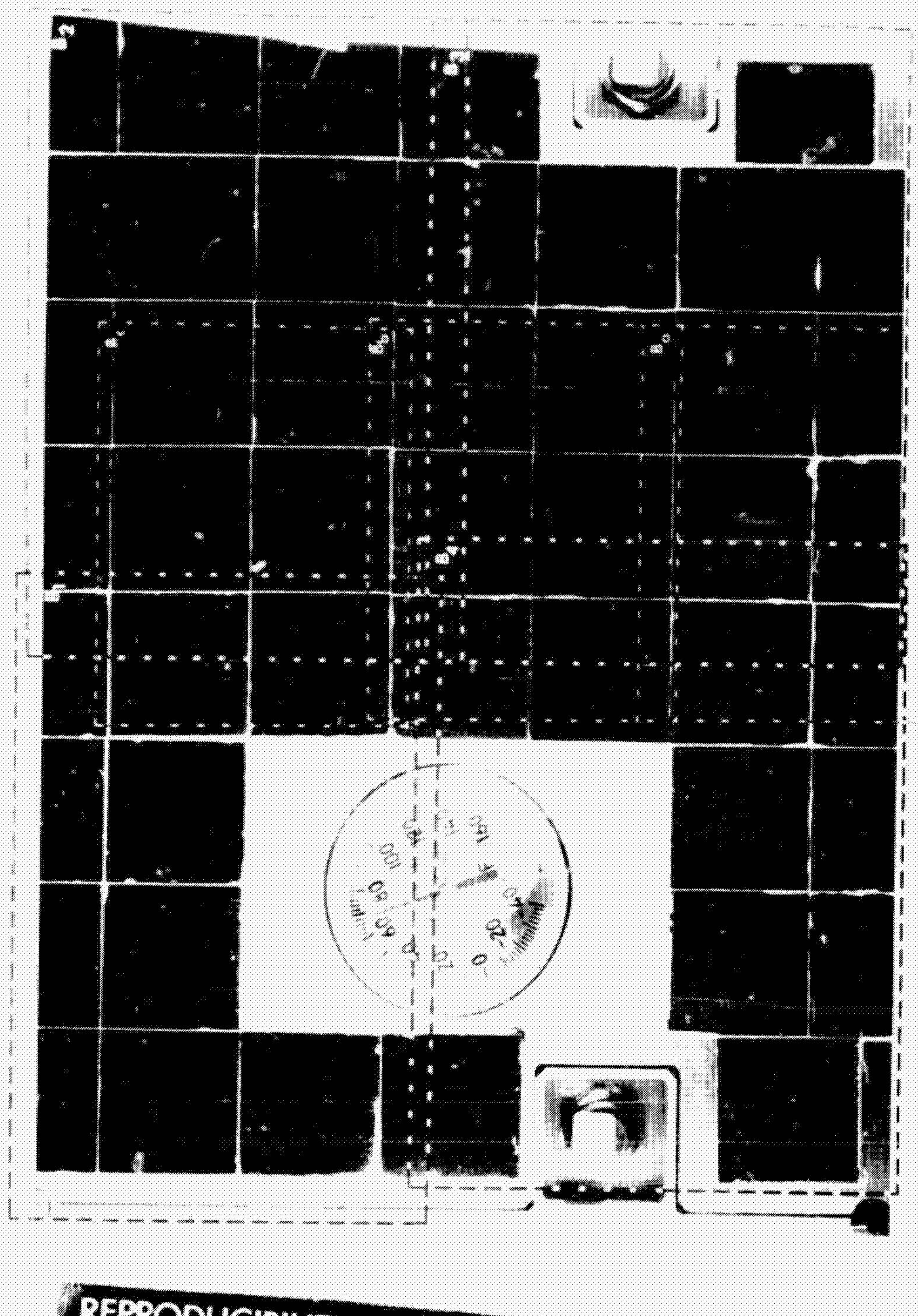


Figure 13. - The SEP experiment receiver, backup unit (SEP-R, B), top mirror. No color picture available (NASA S-73-25916).

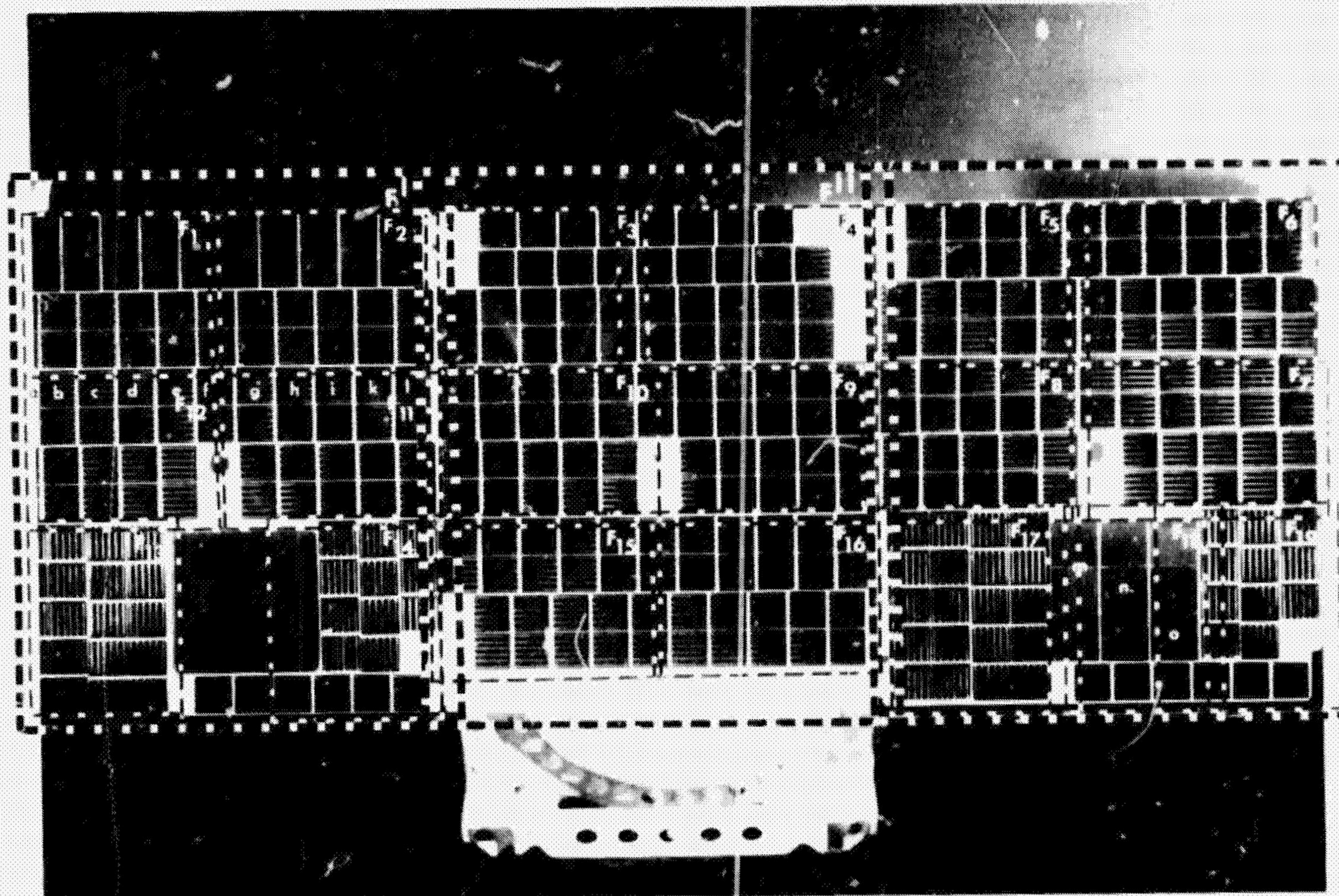


Figure 14. - The SEP experiment transmitter, flight unit (SEP-X, F), glass surface. The designators F', F'', and F''' indicate overall views of individual panels. Note extensive closeup photography at ≈1:3.5 magnification (F_a to F_o). Color pictures available: F and F_1 (NASA S-73-24692).

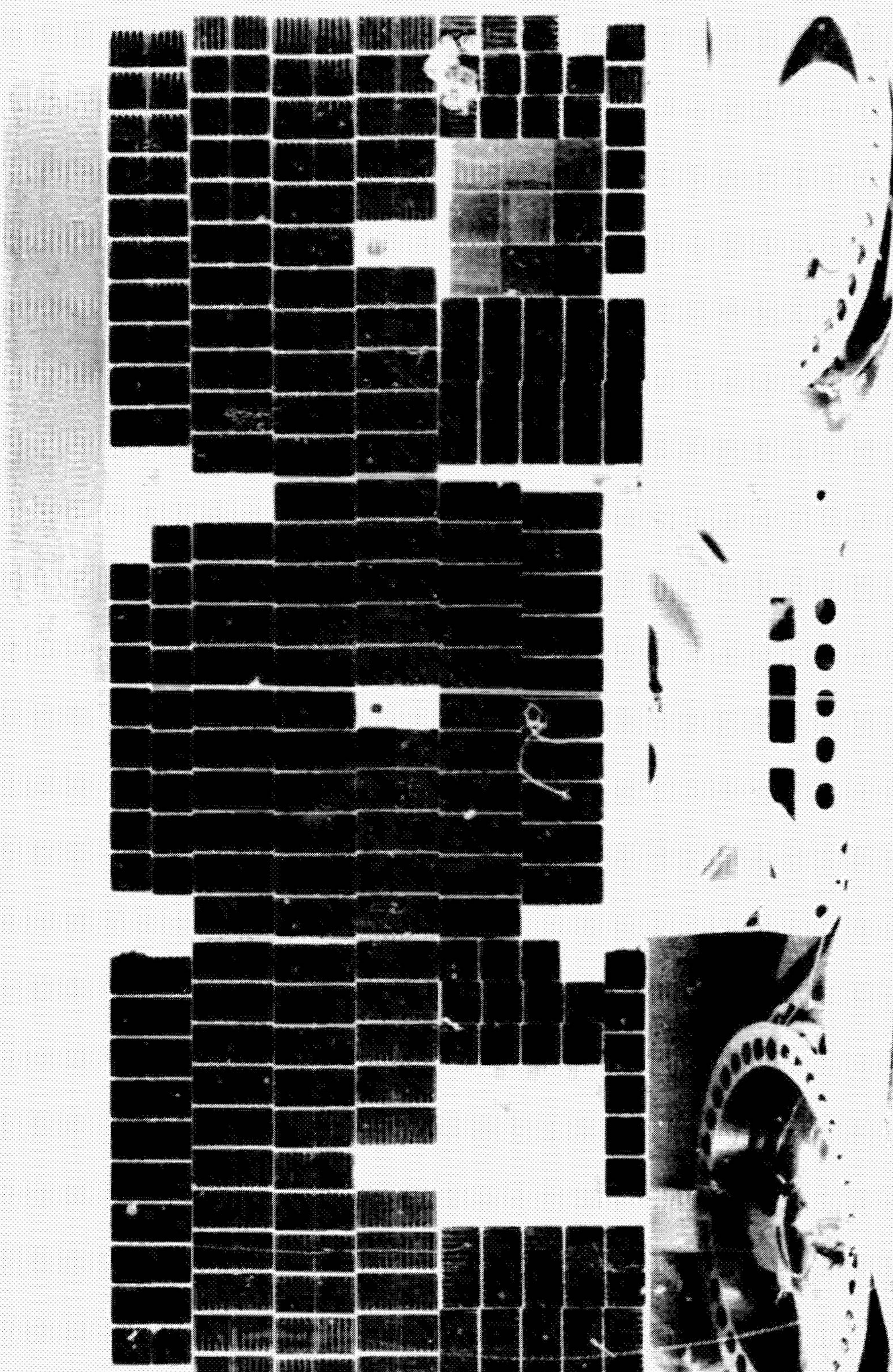


Figure 15. - The SEP experiment transmitter, backup unit (SEP-X, B). Photographic coverage and labeling of frames are identical to those of the flight unit (fig. 14) (NASA S-73-24693).

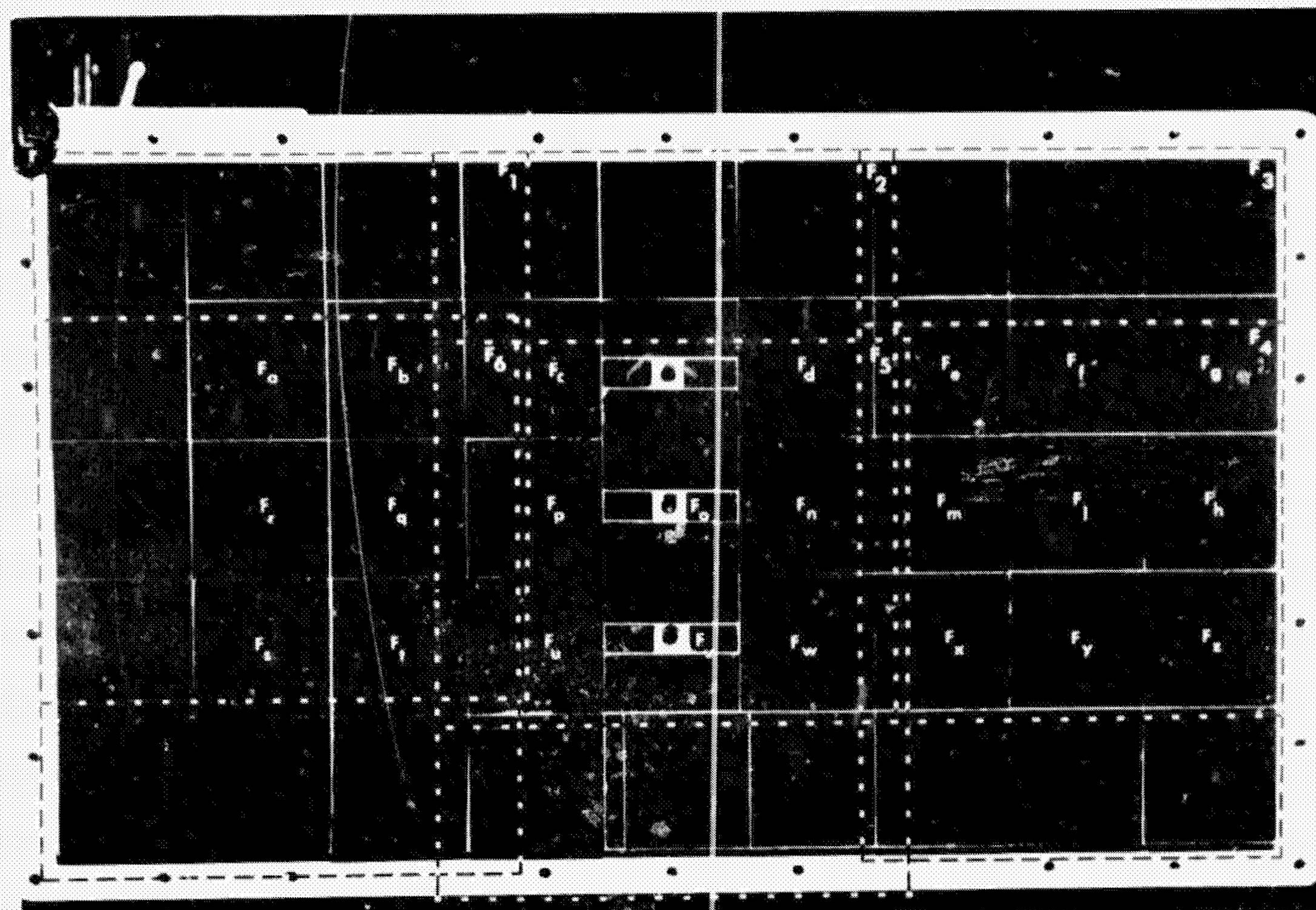


Figure 16. - The CTV camera, flight unit, top mirror (CTV-T, F). Note extensive closeup photography at ≈1:3 magnification (F_a to F_z). Each mirror element is approximately 2.5 by 2.5 centimeters. No color photographs available (NASA S-73-24697).

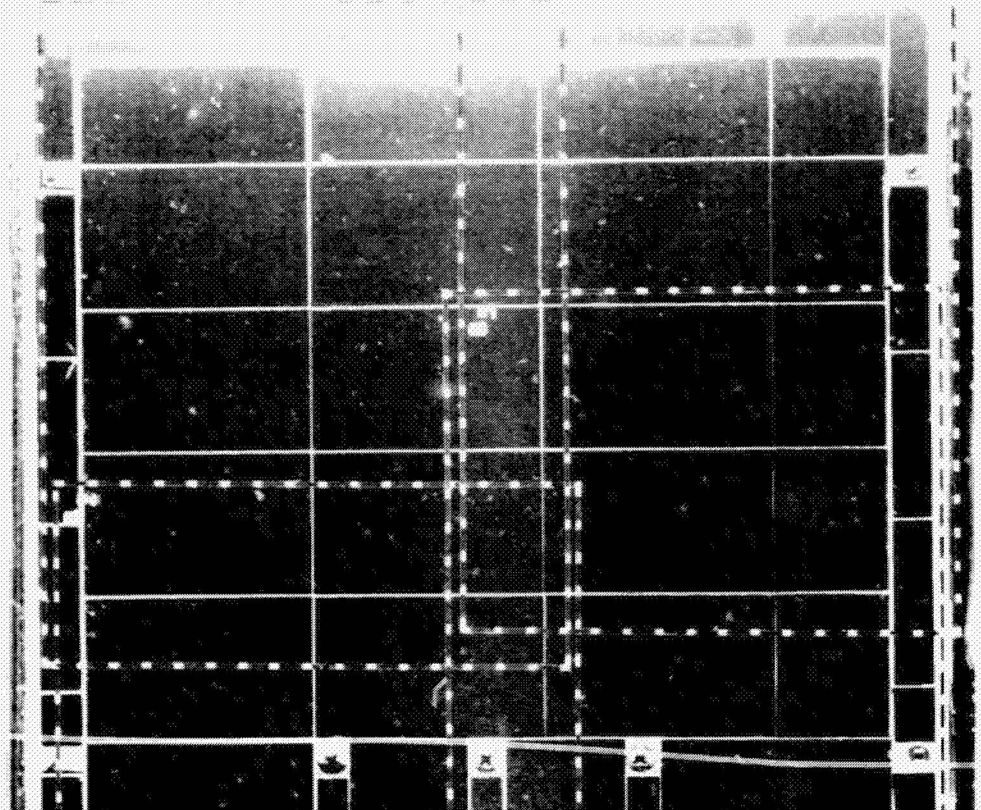
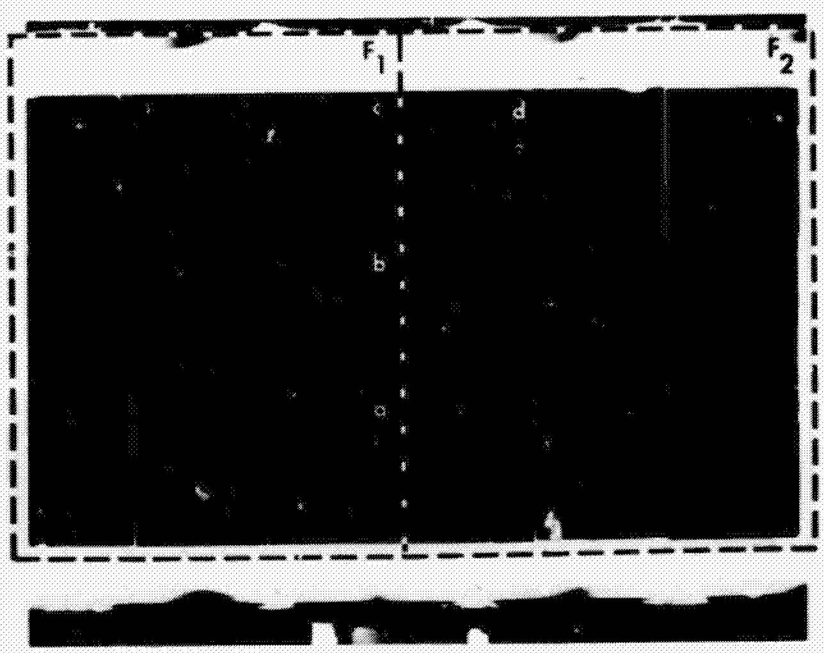
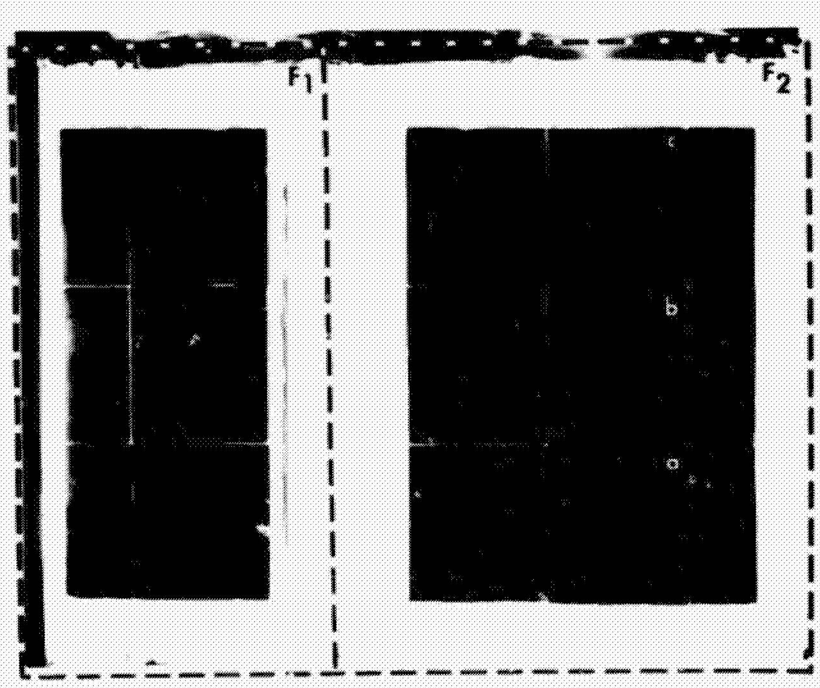


Figure 17.- The CTV camera, backup unit, top mirror (CTV-T, B). No color photographs available (NASA S-73-25913).



(a) Mirror A; TCU-A, F.



(b) Mirror B; TCU-B, F.

Figure 18. - Television control unit (TCU), flight unit, side mirrors. Color pictures available: A, F and B, F (NASA S-73-25923).

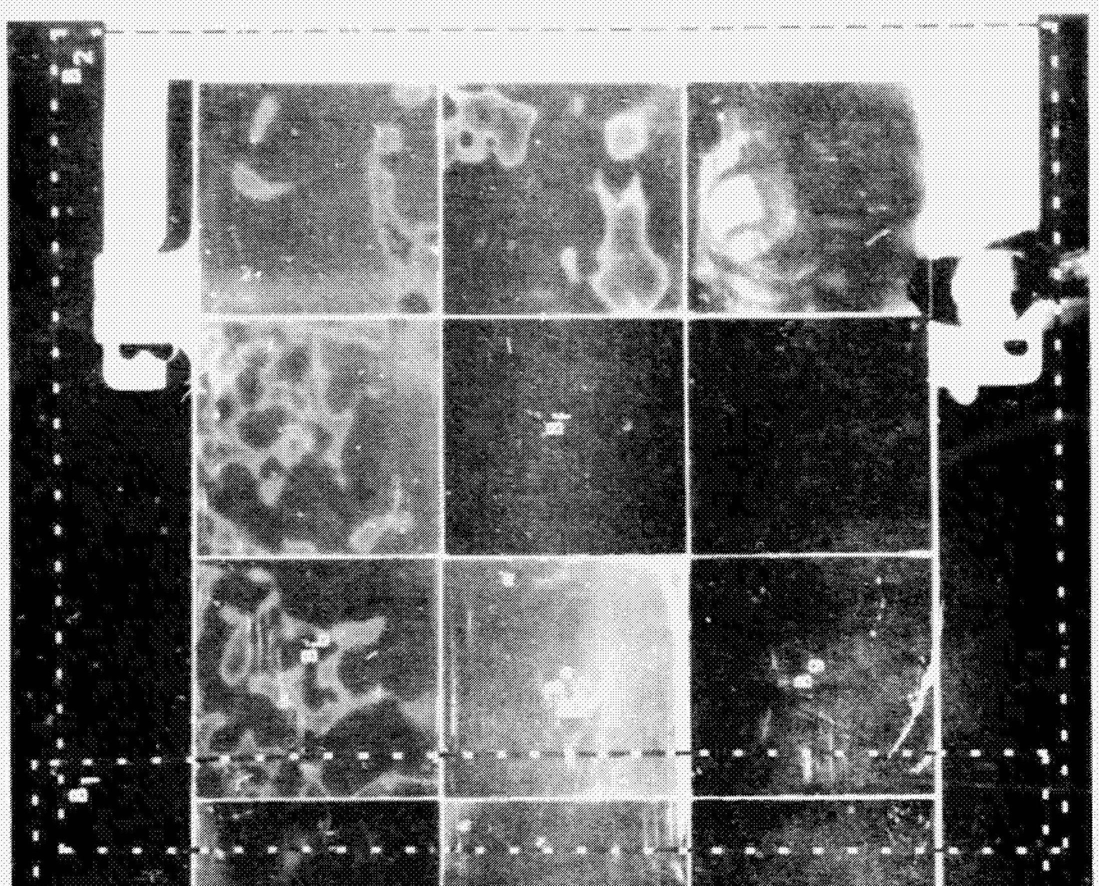


Figure 19. - The TCU, backup unit, mirror A (TCU-A, B) (NASA S-73-25927).

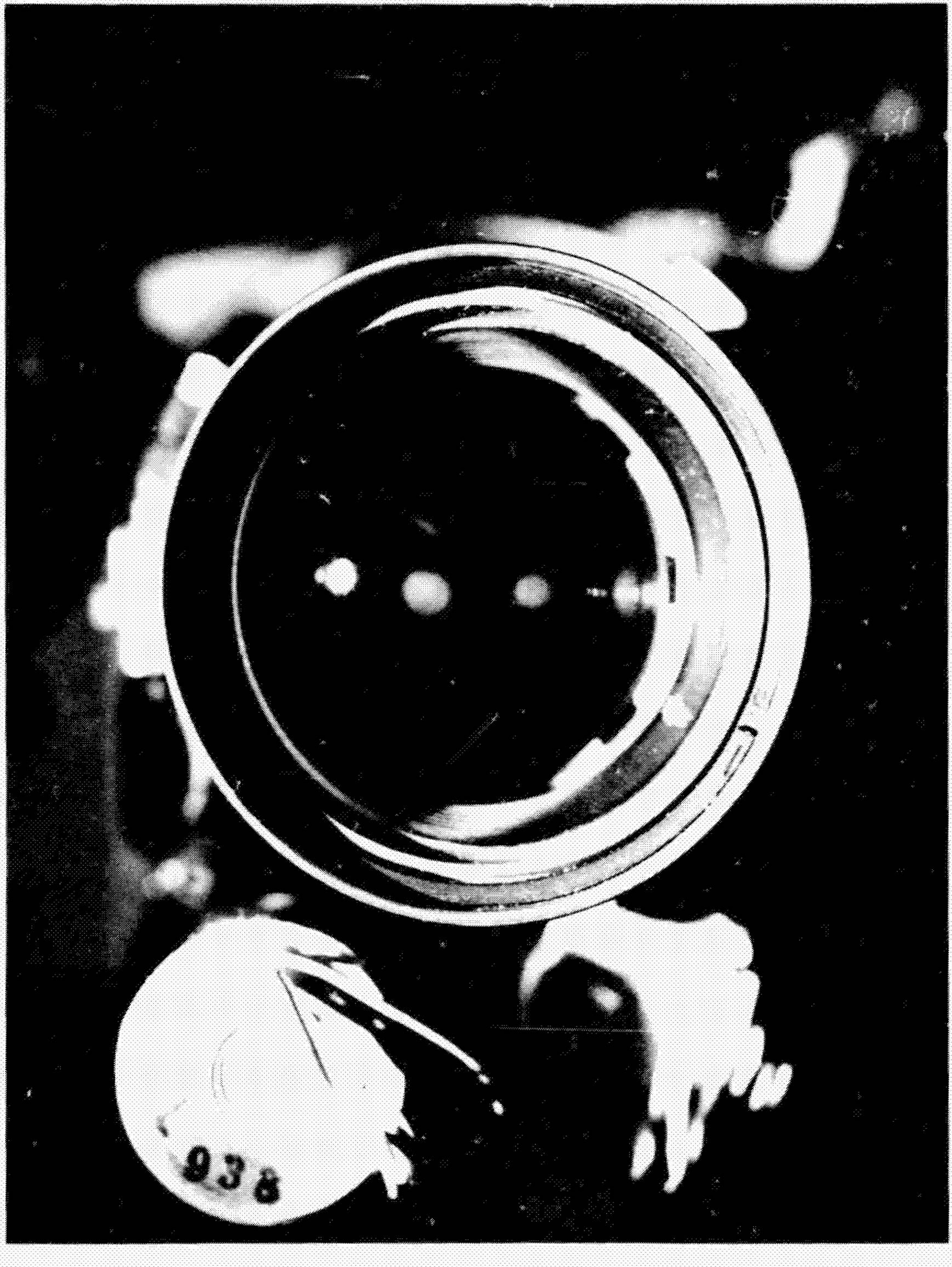


Figure 20. - The CTV camera lens, backup unit. This photograph is representative of all photodocumentation of camera lenses, such as that of the two Hasselblad cameras and the 500-millimeter camera.

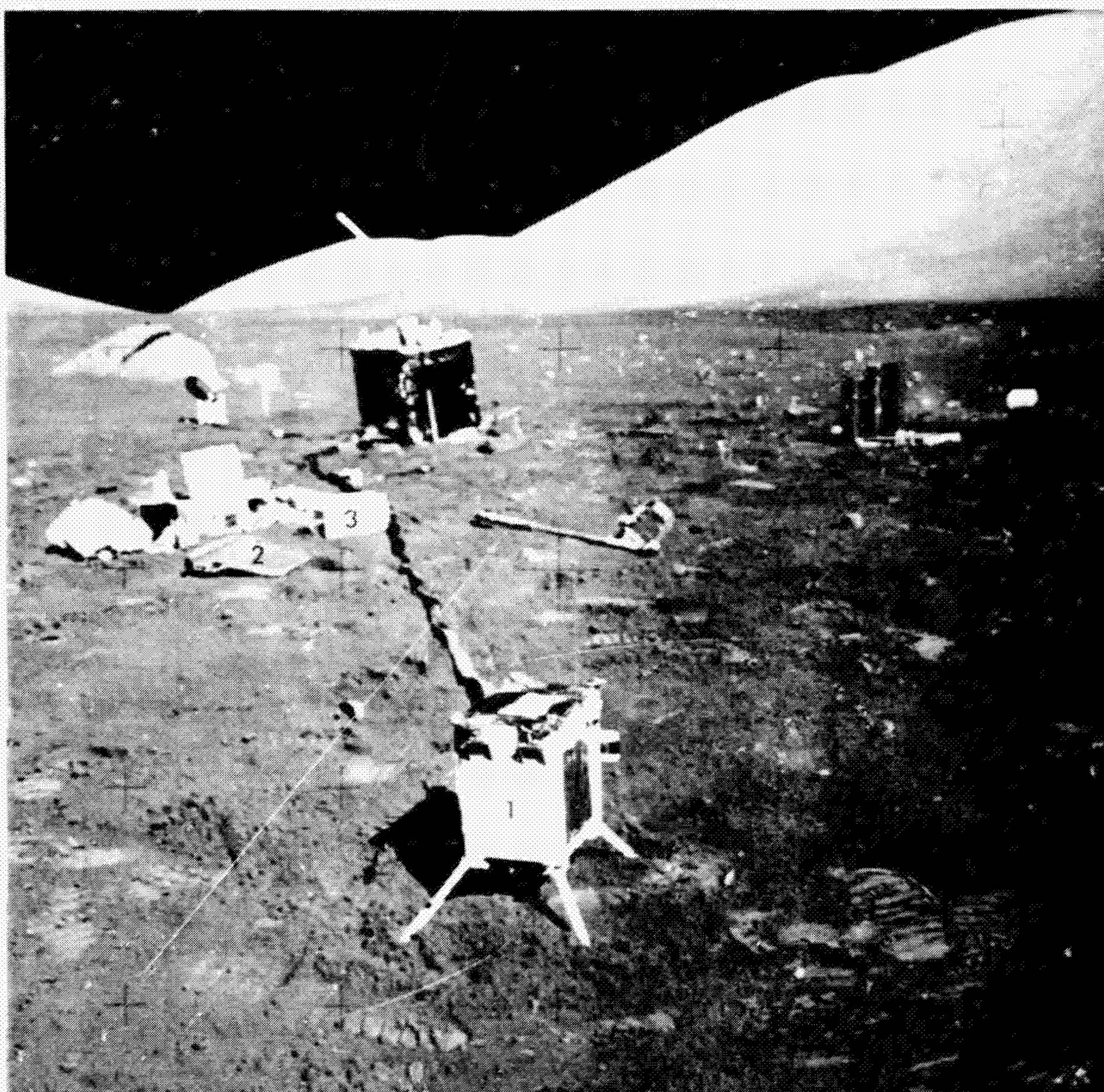


Figure 21. - View of emplaced equipment in the vicinity of the Apollo 17 ALSEP central station. In the foreground is the LEAM (1); left of the central station are the LACE shield (2) and the HAGH box (3) (NASA AS17-134-20500).

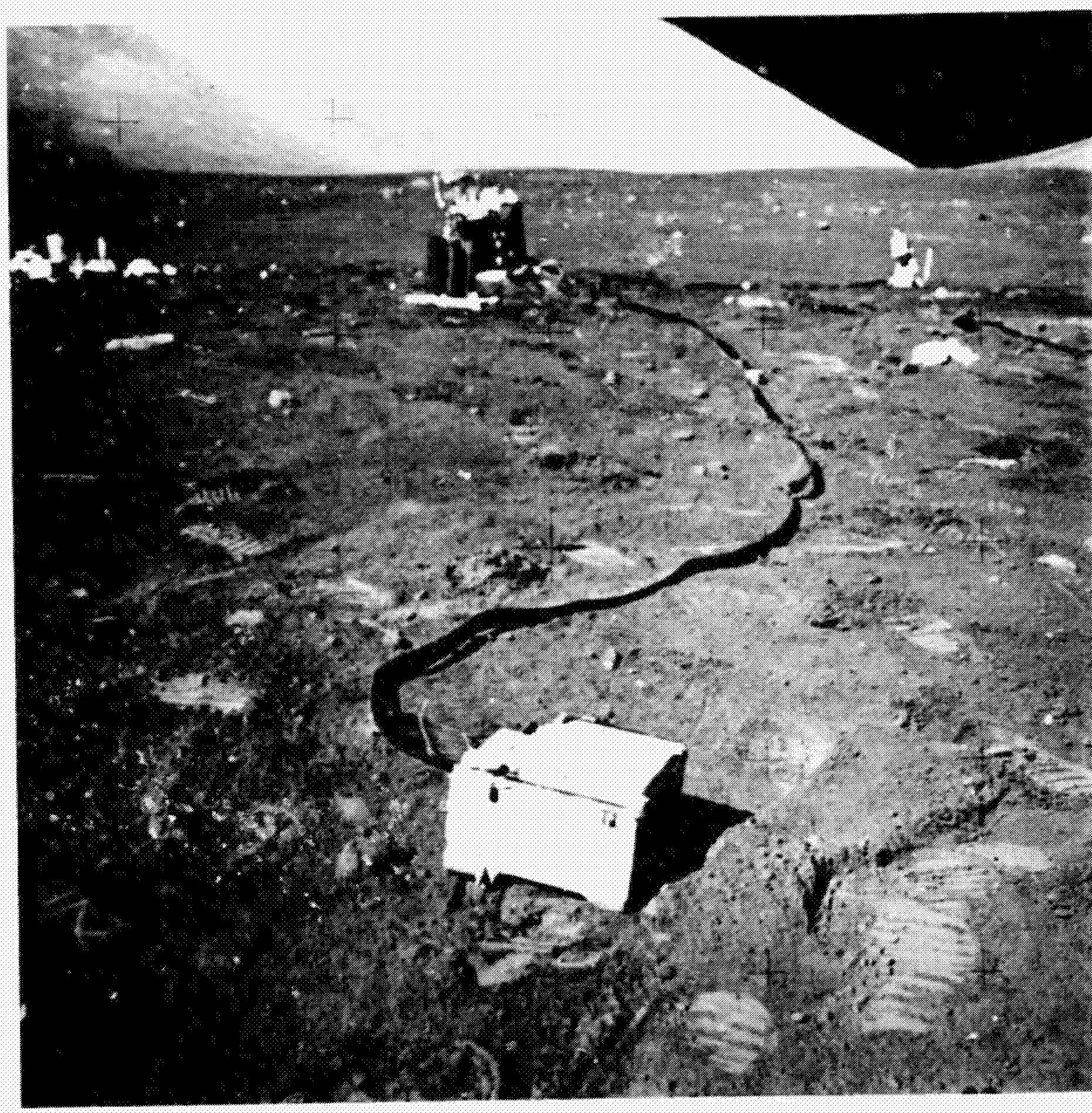


Figure 22. - The LACE (foreground) after deployment. Note that the top lid is still in the closed position; it was opened remotely after lift-off (NASA AS17-134-20499).

Figure 23. - Closeup photograph of the LACE (NASA AS17-134-20498).

Figure 24. - The lunar heat flow experiment and associated electronics box in background. Note the tilted position of the HFE electronics box (NASA AS17-134-20492).

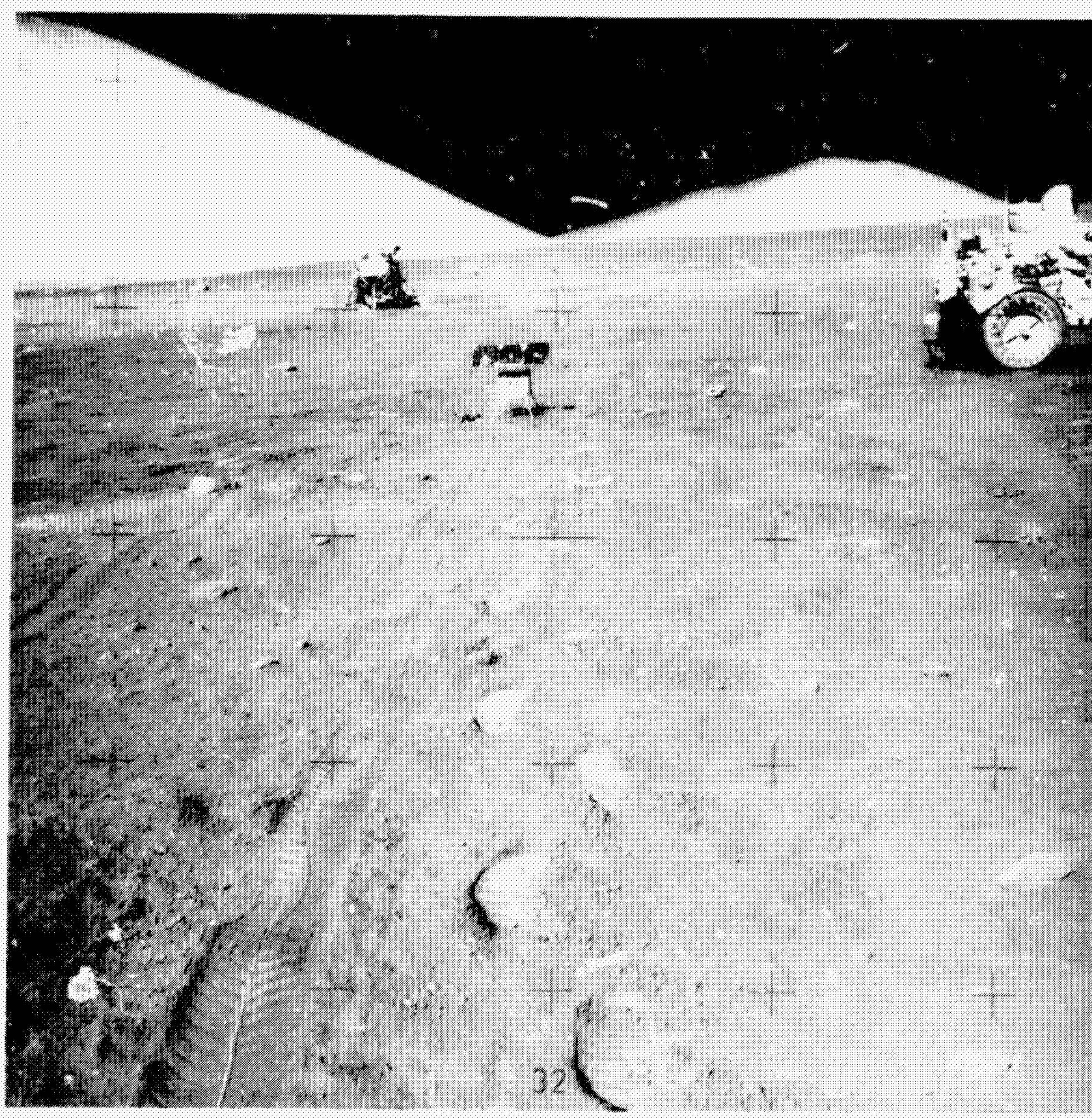


Figure 25. - Photograph showing location of the SEP experiment transmitter (center) with respect to the lunar module (left rear). The LRV can be seen at the right (NASA AS17-141-21516).

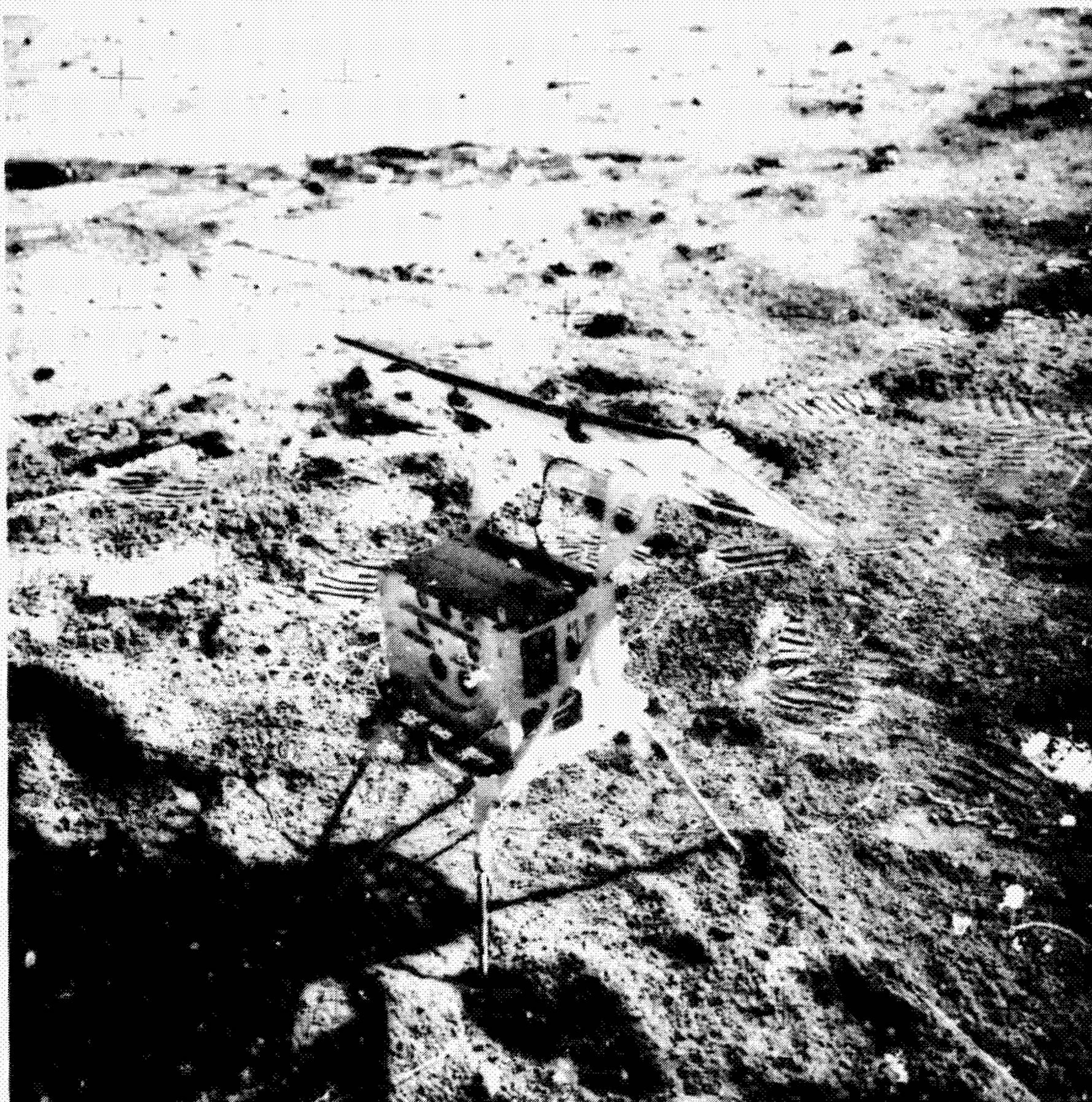


Figure 26. - Closeup photograph of deployed solar-cell array of the SEP experiment transmitter (NASA AS17-141-21510).

Figure 27. - View of the LRV displaying the arrangement of various documented mirror surfaces: (1) LCRU; (2) CTV, top mirror; (3) TCU, mirror A; and (4) TCU, mirror B (NASA AS17-134-20453).

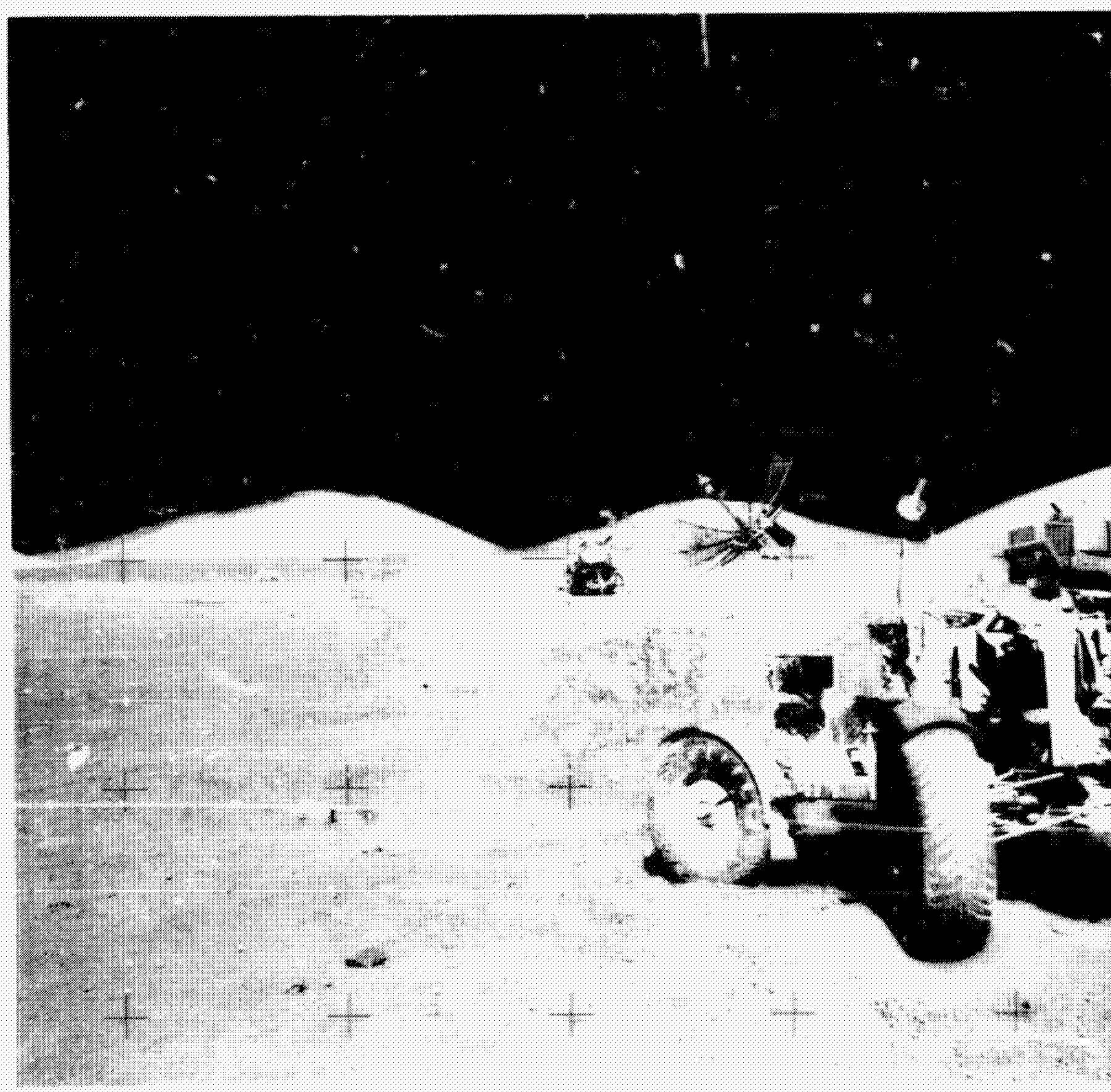


Figure 28. - View showing the location of the LRV (right foreground) with respect to the lunar module (center background) at final parking spot shortly before lift-off (NASA AS17-143-21931).

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